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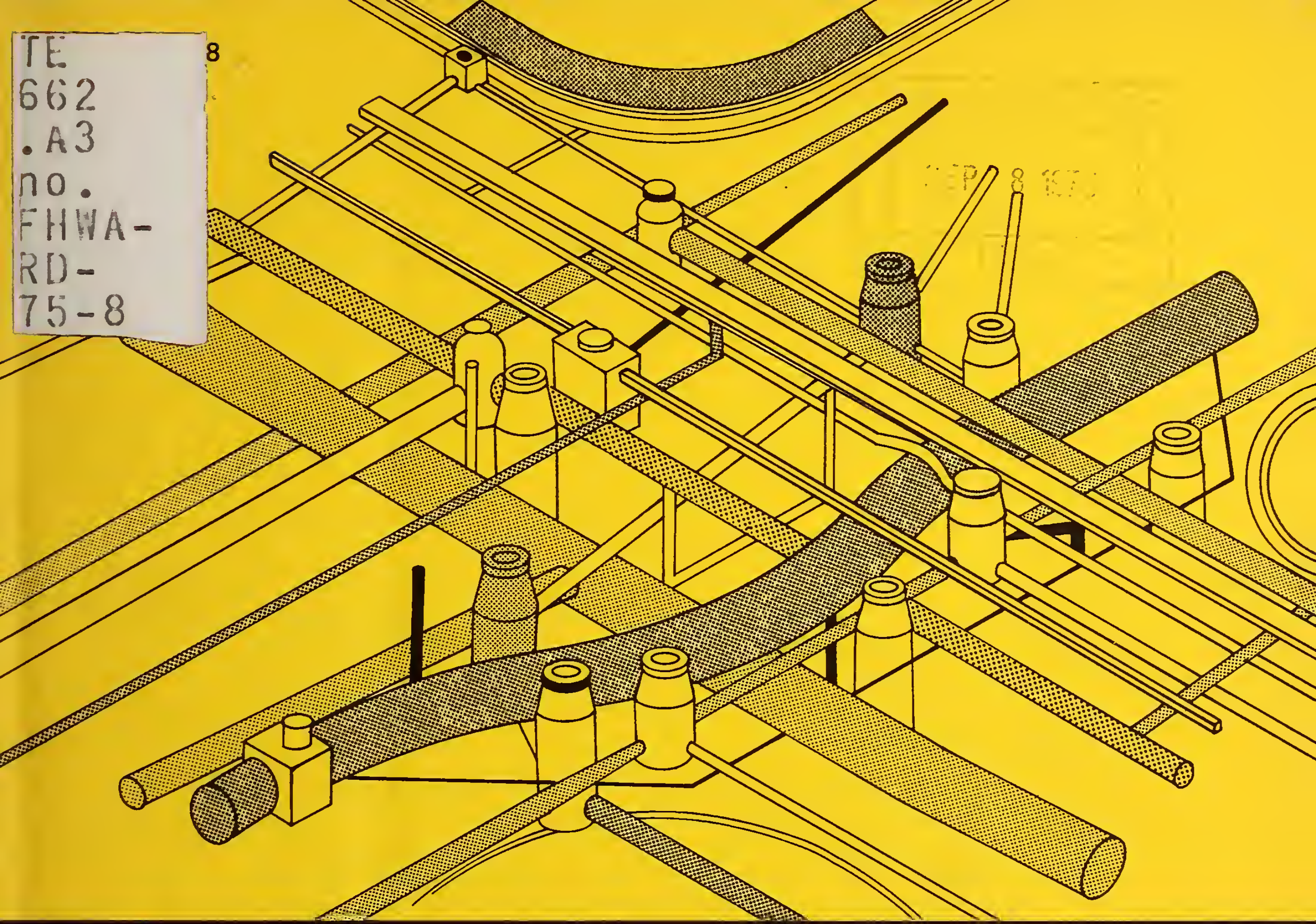

ACCOMMODATION OF UTILITY PLANT WITHIN THE RIGHTS OF WAY OF URBAN STREETS AND HIGHWAYS

State of the Art

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July 1974

DEPARTMENT OF TRANSPORTATION • UNITED STATES OF AMERICA

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16. Abstract

This report presents a technological background and factual practices upon which local agencies could build an effective, workable utility location program. Findings are based on in-depth, on-site interviews of 40 communities in the U.S. and Canada, a mail survey of 500 local agencies, of which 222 submitted replies, and the assistance and cooperation of representatives of all major utility associations, the American Society of Civil Engineers, and the Institute for Municipal Engineering of the American Public Works Association.

It was found to be infeasible to recommend national standards for location of utilities due to the very large number of local and physical factors which influence location practices. Many examples of local standards are given in this report.

Actual constraints, other than physical space for installation and maintenance activities and crossings, are not great for any one utility; however, finite urban space and the infinite needs of expanding utilities have created many problems. In older areas, only gradual improvement in utility location complexities can be anticipated. However, in new and redevelopment areas, steps can be taken now to minimize and prevent future problems.

This report and the companion manual should be of valuable assistance to State and local highway agencies in cooperation with utility companies for making improvements to utility accommodation policies and practices.

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Transmittal of Research Report No. FHWA-RD-75-8, "Accommodation of Utility Plant Within Right-Of-Way of Urban Streets and Highways: State-of-the-Art"

This report and the companion "Manual of Improved Practice" will be of special interest to State and local highway and other agencies responsible for regulating the use and occupancy of urban streets and highway rights-of-way by utility facilities.

The study presents a technological background and factual practices upon which agencies could build an effective, workable utility location program. Examples of local standards are numerous and many are given in this report. It was found, however, to be infeasible to recommend national standards for location of utilities because of the great variation in local institutional and physical factors that influence location practices.

The study points out that actual constraints, other than physical space for installation and maintenance activities and crossings, are not great for any one utility; however, finite urban space and the needs of expanding utilities have created many problems. As a result, only gradual improvement in utility location in older areas can be anticipated. In new and redeveloped areas, however, steps can be taken now to minimize or prevent future problems.

The review on which this report was based involved in-depth on-site interviews of 40 communities in the United States and Canada, a mail survey of 500 local agencies, of which 222 submitted replies, and the assistance and cooperation of representatives of all major utility associations, the American Society of Civil Engineers, APWA's Institute for Municipal Engineering, FHWA and several other national associations and organizations.

W. J. Wilkes
Director, Office of Engineering

Charles F. Scheffey
Director, Office of Research

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Robert J. Lavell, Project Officer
Richard H. Sullivan, Project Director
Robert J. Hoffman, Principal Investigator

APWA STAFF

Kendall E. Bert
C. Richard Kuykendall
Martin J. Manning, P.E.

CONSULTANTS

Dr. Morris M. Cohn, P.E. – Staff Consultant
Robert E. DeLoach, P.E.
Harold T. Harris
William D. Hurst, P.E. – Staff Consultant
Roy W. Morse, P.E.
Robley Winfrey, P.E. – Staff Consultant

STEERING COMMITTEE

Member/Affiliation	Representing
John B. Corey, Chairman Chief Water Engineer City of Chicago Room 403 – City Hall Chicago, Illinois 60602	The Committee on Streets and Traffic of the Institute for Municipal Engineering (APWA-IME)
W. R. Bristow Northern Illinois Gas Company P. O. Box 190 Aurora, Illinois 60507	American Gas Association (AGA)
W. A. Campbell Chief Engineer of the Electric Power Board 6th & Market Streets Chattanooga, Tennessee 37402	The American Public Power Association (APPA)

ACKNOWLEDGEMENTS (Continued)
STEERING COMMITTEE

Member/Affiliation	Representing
D. E. Farrington Planning Director City of Fort Worth City Hall Fort Worth, Texas 76102	The American Society of Civil Engineers (ASCE) – (Co-representative)
John H. Ferguson Consulting Engineer 9817 Kingsley Road Dallas, Texas 75238	The Committee on Streets and Traffic of the Institute for Municipal Engineering (APWA-IME)
James Foley Director, Office of Driving Environmental Programs Highway Safety Programs Service Federal Highway Administration 400 – 7th Street, S.W. Washington, D.C. 20590	The Committee on Streets and Traffic of the Institute for Municipal Engineering (APWA-IME)
Jack M. Graham Director of Public Works City of Fort Worth 1000 Throckmorton Street Fort Worth, Texas 76102	The Committee on Streets and Traffic of the Institute for Municipal Engineering (APWA-IME)
William L. Griffith Oak Ridge National Laboratory P. O. Box X Oak Ridge, Tennessee 37830	Oak Ridge National Laboratory (ORNL)
*Anton H. Harwig Director of Public Works City of Elmhurst 119 Schiller Street Elmhurst, Illinois 60126	The Water Pollution Control Federation (WPCF)
Albert R. Heidecke Assistant Director of Real Estate Commonwealth Edison Company One First National Plaza Chicago, Illinois 60690	The American Right-of-Way Association (AROWA)
Charles Henry Badger CATV 203 Stephenson Avenue Iron Mountain, Michigan 49801	National Cable Television Association (NCTA)

ACKNOWLEDGEMENTS (Continued)
STEERING COMMITTEE

Membership/Affiliation	Representing
Walter A. Hoye Assistant Engineer-in-Charge Water Operating Division Room 1441-B 111 North Hope Street Los Angeles, California 90051	The American Water Works Association (AWWA)
William T. Killeen City Engineer City of Birmingham 151 Martin Street Birmingham, Michigan 48012	The Committee on Streets and Traffic of the Institute for Municipal Engineering (APWA-IME)
James E. Kirk Chief, Railroad and Utilities Branch Office of Engineering Federal Highway Administration 400 – 7th Street, S.W. Washington, D.C. 20590	The Federal Highway Administration (FHWA)
E. G. Outlaw Public Service Electric and Gas Co. 80 Park Place Newark, N.J. 07101	Edison Electric Institute (EEI)
John M. Peacock Engineering Manager Outside Plant Facilities Design American Telephone & Telegraph Co. 195 Broadway – Room 1942-B New York, N.Y. 10007	The American Telephone & Telegraph Company (AT&T)
A. R. Phillipich Engineer of Utilities and Permits Michigan State Highway Department 425 West Ottawa P. O. Drawer K Lansing, Michigan 48904	The Task Force on Utilities of the Highway Research Board (HRB)
Woodrow W. Rankin Traffic Research Engineer Highway Users Federation 1776 Massachusetts Avenue, N.W. Washington, D.C. 20036	The Committee on Streets and Traffic of the Institute for Municipal Engineering (APWA-IME)

ACKNOWLEDGEMENTS (Continued)
STEERING COMMITTEE

Member/Affiliation	Representing
Paul H. Sanders Assistant Director School of Civil Engineering Georgia Institute of Technology Atlanta, Georgia 30332	The American Society of Civil Engineers (ASCE)
Joseph A. Seta President Joseph A. Seta, Incorporated 4506 Hanley Road Cincinnati, Ohio 45239	The Associated General Contractors (AGC)
* Richard Spicer Senior Research Associate American Society of Planning Officials 1313 East 60th Street Chicago, Illinois 60637	The American Society of Planning Officials (ASPO)
Donald C. Tillman City Engineer City Hall Los Angeles, California 90012	The Committee on Streets and Traffic of the Institute for Municipal Engineering (APWA-IME)
G. E. Tubb General Engineer Outside Plant and Transmission Bell Canada 1050 Beaver Hall Hill Montreal 128, Quebec, CANADA	Bell Canada

* No longer a member.

SPONSORING AGENCIES
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ACKNOWLEDGEMENTS (Continued)
SPONSORING AGENCIES
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UTILITIES

American Telephone & Telegraph	J. M. Peacock
Baltimore Gas & Electric Company	E. F. Muller, Jr., P.E.
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Southern California Edison Company	E. H. Clark
Springfield Gas Light Company (now Bay State Gas Company)	Roger G. Whitehill
United Illuminating	Charles Walters
Wisconsin Electric Power Company	Donald H. Gordon

FOREWORD

The APWA Research Foundation has welcomed the opportunity to study the problems involved in the location, servicing and maintenance of publicly-owned and privately-owned utilities within public rights-of-way. These problems constitute one of the most important matters that local public works officials must deal with each day.

This report, sponsored by the U.S. Federal Highway Administration and 25 municipalities, 7 states, 15 utility companies and the American Society of Civil Engineers, presents a comprehensive overview of the present state of the art. The accompanying Manual of Improved Practice sets forth recommendations on practice that should be pertinent and applicable, in whole or in part, to most local governments and utilities.

The study has sought to present a technological background and factual practices upon which local agencies could build an effective, workable utility location program. It was found to be infeasible to recommend national standards for location of utilities due to the very large number of local and physical factors which influence location practices. Examples of local standards are numerous and many are given in this report. Actual constraints, other than physical space for installation and maintenance activities and crossings are not great for any one utility; however, finite urban space and the infinite needs of expanding utilities have created many problems.

In older areas, only gradual improvement in utility location complexities can be anticipated. However, in new and redevelopment areas steps can be taken now to minimize and prevent future problems.

As an expression of its concern for the problems of utility location and coordination, the APWA has formed a Utility Location and Coordination Council within its structure to address the problems and opportunities for improving this facet of community operations and growth on a continuing basis.

John B. Corey
Chairman
Steering Committee

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CHAPTER I
INTRODUCTION AND OVERVIEW

Introduction

Practices for accommodating utilities in public street rights-of-way vary widely among communities in the United States and Canada. There is, however, a commonality of organizational arrangements and regulating and control mechanisms and problems which affect most communities. An examination of these practices and problems can identify best current practices, indicate areas where further research and improvement are needed, and point the way toward alleviating some of the most widespread and serious needs.

A series of utility networks lace all urban communities with systems of cables and pipes that provide essential energy, communication, water, sewage, drainage and other services and commodities that make modern urban life possible. For the most part, these utility networks are superimposed over, and underlie the network of urban roads and streets. While most of the older existing electric power, telephone and other cable-transmitted services are placed overhead on poles located in street rights-of-way and rear lot easements, there is a noticeable trend toward placing new distribution systems underground and converting existing aerial facilities to underground.

This trend toward undergrounding, compounded by continued urbanization of the country and residential and commercial construction, population growth, increased per capita demands for utility services, and the advent of new utility services such as cable TV (and perhaps others such as pneumatic tubes and vacuum waste collection systems) will increase the congestion of subsurface space and exacerbate the problems attendant to this congestion.

Accidental utility line dig-ups – a serious nationwide problem – are but one manifestation of the problem. The crowding of subsurface space, the haphazard location of many older utility lines, and the lack of reliable underground utility location information, complicate the problems of installing and maintaining utility systems. The need to protect workmen, pedestrians, vehicles, and neighboring utilities, to minimize traffic delays and inconvenience to abutting properties, to reduce noise and to prevent other environmental hazards, has made utility work in street rights-of-way difficult and costly, and adverse side effects still occur in spite of efforts to minimize them. The number of different types of utilities found in most city streets and the diffuse pattern of utility ownership and management responsibilities make coordination of utility work in street rights-of-way difficult.

Many governmental agencies have developed procedures and practices to alleviate these problems and to provide for more efficient and orderly use of space. Some of these approaches appear to be working well. Agencies not presently employing these proven practices would do well to adopt or adapt them. In other instances, however, the identification of *best practice* is not so clear-cut – only subjective judgments are available to assess the relative costs and benefits. Even when assessable, it is likely that practices that work well under one set of circumstances may not work so well under others. Not enough is known about the effects of institutional and environmental differences among communities to predict the successful transferability of particular policies from community to community. It is likely that local adaptations will be necessary to implement identifiable *good* practices. In some areas, no *models* appear to exist. Better approaches must be conceived. Additional research and development would be useful, particularly to improve product reliability, reduce size and decrease cost. Following are some of the major observations about the state of the art which resulted from the study.

Overview

In the United States, and to only a slightly lesser extent in Canada, the provision of utility services is characterized by a pattern of diffused ownership. Water and sewage service is usually provided by a publicly-owned agency – a municipality, special district or authority – although a number of investor-owned water utilities are in operation. Electric power, telephone, and natural gas are typically privately-owned utilities although there are a number of municipal and other publicly-owned electric and gas utilities. Street lighting and emergency signal systems may be owned and operated either by public agencies or investor-owned companies. The pattern varies from community to community.

Twelve different types of utility services are provided in most urban areas. In one community, for example, one municipal department, two other governmental agencies and four investor-owned companies provide utility service in a municipality. In another case, the total number of different utility agencies reported was 27.

A number of different agencies and municipal departments are involved in utility regulating, planning, or control process. Typically, a State Public Utilities Commission or Public Services Commission regulates utility rates and may prescribe certain practices such as undergrounding. The State legislature and/or city councils may grant utility franchises and impose certain restrictions. A local planning commission may establish subdivision regulations and zoning districts which affect utilities. The public works department or city engineer may regulate street openings. The traffic engineering or police departments may regulate lane closings and traffic protection measures. A state or Federal agency may prescribe safe work practices. A state highway department may regulate utility work in state rights-of-way passing through municipalities.

Each of these regulatory agencies, and each utility service agency (privately- or publicly-owned) has its own clientele to serve, its own interests to protect and its own individual perspective on the problem of utility accommodation. One wants to maximize the return on its investment; another wants to minimize rates; another wants to protect workmen; another wants to reduce traffic congestion; another wants to prevent damage to the pavement; another wants to beautify the community, and so on. Measures designed to optimize one of these objectives often conflict with others. Each resolution of a problem ultimately has an effect, even if not always measurable, on a variety of groups – the utility company and its customers, the municipality and the taxpayer, the motoring public, the abutting property owner or resident and a number of other affected individuals or groups.

Under present diffused ownership and control arrangements there is no incentive (and plenty of disincentives) to look at total systems costs – the sum total of the effects of accommodation practices on all affected parties. Consequently, the net total effect of existing practices is unknown; neither is it known whether proposed changes will have a net beneficial or negative net effect.

Immense theoretical and practical problems must be overcome both in determining total system costs and in applying this concept to real world situations. Where to draw the boundaries of the system, i.e., what *costs* to include, and how to measure or recognize certain environmental and social effects are both problems. It should also be recognized that *minimum total system cost solutions* which result in the redistribution of immediate costs and benefits among affected parties may be difficult to implement due to the political and economic power of the affected groups. In spite of these difficulties, it seems advisable to develop mechanisms for providing a broader perspective toward the problems, for evaluating trade-offs, for resolving conflicts, and for implementing solutions in terms of the broadest possible *public interest*.

Utility Coordinating Committees

Utility coordinating committees, composed of representatives of privately-owned utility companies, governmental utility agencies, regulating bodies, and other interested groups have been voluntarily formed in a number of communities in the United States and Canada to coordinate their utility location problems and corrective programs for their mutual benefit. The composition, structure, legal status, authority, activities and effectiveness of these organizations vary from place to place. In most cases, these committees are organized on an informal basis, meet on call as the need arises, and have no formal powers, responsibilities, or continuing programs. They often serve as a focal point for the exchange of information and the resolution of problems through dialogue and the mutual consent of the participants.

In a minority of cases, the committees are formally organized with officers and by-laws, meet on a regularly scheduled basis, employ a staff, have an operating budget (financed from assessments levied on participating agencies), have authority to recommend decisions to some higher authority (in a very small number of cases, to make binding decisions), and carry out some on-going programs which may include: centralized record keeping, public information campaigns, *one call* and *locate and stake* programs, development of utility location guidelines or standards, and coordination of the plans and programs of participating agencies.

It is clear that these utility coordinating committees perform a useful service and should be formed where they do not exist. (Forty-six percent of the communities in the United States and Canada have no utility coordinating committees – formal or informal.) Although the structure and programs of these committees should reflect local needs and circumstances, the apparently more successful groups tend to be those organized on a more formal basis with adequate staff and fiscal resources.

Although utility coordinating committees can be effective coordinating instruments, in most cases they do not have the authority to determine certain public policies and plans which directly bear on the utility accommodation process, but they may be able to focus attention on various planning problems. In too many cases overall city planning and utility planning are carried on as independent efforts. City plans are developed – and changed – often with little regard for the effects of those decisions on utility networks. Rezonings and unplanned-for high density developments can have major impacts on the utility system, requiring the installation of miles of new trunk facilities, with attendant street openings and traffic disruptions. Vacating existing street or alley rights-of-way can eliminate utility access to private property through those rights-of-way. The granting of building encroachments into right-of-way subsurface space can preempt an alignment needed for utility purposes.

Thoroughfare plans are developed primarily to meet transportation needs; often little attention is given to utility space requirements. Right-of-way widths are set to accommodate traffic and parking lanes, sidewalks, and planting strips. Utilities are then fitted, as best as they can be, into available space. Likewise, street furniture such as street lighting standards, hydrants, and traffic control devices are often not planned for nor adequate space provided.

Little thought is given either to providing adequate space for utilities or to organizing space utilization in a manner that will minimize conflicts between using that right-of-way for both transportation and utility purposes. When highway grades, alignments, or widths are changed, utilities are usually required to relocate at their own expense. Too little thought is given to planning for this eventuality. Many municipalities do not have long-range capital improvement plans for streets and municipal utilities, and do not adequately coordinate development plans to avoid cutting new pavements for utility work.

When acquiring additional right-of-way for street improvements, most public agencies do not obtain the extra right-of-way that may be needed for either municipally- or investor-owned utilities. In practice, utility considerations are practically ignored in the planning process and utility rights in public rights-of-way are definitely subordinated to other interests. The result is not in the best public interest. Better understanding needs to be developed of the interrelationships between the city and utility planning processes. Utility concerns should be better represented in the planning process; better capital improvement planning should be undertaken; and additional efforts should be made to communicate and coordinate decisions and plans with affected parties.

Record Systems

The comprehensiveness, accuracy, currency and accessibility of utility location maps and records varies from municipality to municipality and from utility to utility. There are some excellent record-keeping systems but many are deficient in one or more respects. Common deficiencies include:

- failure to record *as built* conditions (field changes are often made from planned alignments and not noted)
- out of date records (locations may be referenced to original features such as curbs which may subsequently have been relocated)
- delays in updating maps (there may be months of field notes backlogged)
- errors in field measurement or in plan dimensioning; incomplete records (no records exist for many older systems); and
- failure to show service connections.

Generally each utility is responsible for keeping records of the location of its own utilities. Central repositories of information, or master mapping of the location of all utilities in public street rights-of-way are uncommon, and most of these are incomplete.

The vast majority (99%) of municipal location records exist in the form of engineering drawings or utilities maps; microfilm records are kept by about 23 percent of the municipalities; and only one percent of all municipalities are using computerized records; five percent of all municipalities use a geocoding coordinate system for storing utility data.

It is clear that improvements are needed in utility record-keeping systems and procedures. Greater care and effort should be devoted to gathering and recording utility location information; available technology for information storage, processing, and retrieval should be more widely utilized; and mechanisms should be developed and implemented for facilitating the compilation of all utility location information in a particular area, either through centralized record-keeping arrangements or through the use of modern telecommunication links to the individually maintained record systems of all utility agencies.

Field Location and Substructure Damage Prevention

Most utilities are actively engaged in substructure damage prevention programs. Eighty-seven percent have a *call before you dig* program although in only 35 percent of the communities is there a central telephone number to reach all utilities. Almost all (95-98%) of the water, sewer, gas, telephone, and power utilities provide a field location service to locate buried facilities. However, a sizeable portion (30-50%) of these programs depend entirely on records to mark the location of buried utilities (as indicated previously, record systems are not always reliable). Instruments are used about 50-60 percent of the time and in only about 13-15 percent of the cases are lines actually uncovered by test digging.

Additional efforts are needed in this area. *Call before you dig* and *locate and stake* programs should be installed in all areas. More intensive public and contractor education programs should be undertaken. Convenient *one call* systems should be developed to encourage public cooperation. Less reliance should be placed on records to locate underground utilities and more use should be made of instruments and hand digging to verify locations. Better instruments should be developed for locating utility plant, particularly non-metallic conduits.

Permit and Inspection Programs

In almost all communities, the use of street rights-of-way for utility purposes is regulated by the municipality. Permits are normally required to cut street pavement except in emergencies. Fees are normally charged for each permit. Performance or surety bonds are normally required from private contractors and are frequently required from utility companies. Municipal departments are often exempt from these permitting requirements.

Permits normally regulate or specify the extent and method of work (open cutting is prohibited under certain circumstances), hours of work, signing and barricading, vehicular and pedestrian safety measures, protection of other utility facilities, backfilling, pavement restoration, cleanup and other operations.

Although permit requirements are often very stringent, field inspection is often less than adequate to enforce these requirements. Backfilling, compaction and pavement restoration are frequently inadequately controlled.

Generally, municipal permit systems for utility work in street rights-of-way work fairly well. Improvements are needed, however, in the areas of: simplification of administrative procedures to make it more convenient for the permittee to obtain a permit; subjection of the municipal departments to the same necessary and reasonable procedures and standards required of other utility agencies and contractors; and provision of better field inspection, particularly for backfilling and pavement restoration.

Pavement Restoration

In order to minimize problems with improperly restored pavements, about 36 percent of the municipalities surveyed perform pavement restoration work with their own forces. Almost all, however, permit the utility company or its contractor to backfill the trench, make the temporary pavement restoration, and maintain the temporary pavement. Municipalities that have chosen to provide surface restoration maintain that it works well for them, although restoration by municipal forces is no guarantee of superior work. Other cities which specify good pavement restoration standards and provide adequate inspection report satisfaction with the restoration work performed by utility companies or their contractors. Each municipality must judge the adequacy of its own procedures, identify the cause of any deficiencies, and apply its own remedies. One improvement that might prove of general benefit, however, is in the area of backfill materials. Some cities have experimented with *unshrinkable fills* (a weak soil-cement mixture) and mixtures of crushed pavement and excavated spoil with good results.

Utility Location Standards

A number of communities have developed guidelines to standardize the location of utilities in street rights-of-way and to use scarce space more efficiently. These standard locations vary from community to community and clear-cut patterns are not easily discernible. It seems that each local standard is a product of a number of organizational, technical, traditional, environmental, and other considerations unique to that community. Thus transferability to other areas is often indeterminate. There is little documentation to indicate why, or by what process, the final determinations were made. The rationale for supporting particular locational preferences seems weak in many cases.

Although there undoubtedly is no one best arrangement for all circumstances, there probably is one best arrangement for each particular set of local conditions. Formulation of a model by which optimum locational arrangements can be developed for each set of circumstances would be of value. This, however, is a most complex undertaking due to the difficulty of identifying all the relevant constraints, requirements and variables; the difficulty in identifying and measuring the effects of various locational alternatives on total system costs or some other indicator of overall system effectiveness; and the lack of uniform data on utility installation and maintenance costs, among others.

The potential benefits of this approach, however, would seem to warrant the pursuit of such a model. Falling short of being able to identify *optimum* utility arrangements, *workable* arrangements that provide for some regularity and predictability in utility locations within a community would be of considerable benefit and should be developed.

Joint Use Facilities

The joint use of utility poles by two or more utility types – power, telephone, telegraph, etc. – is widely practiced to cut costs and minimize street clutter. Joint trenching, however, is not so widespread. It is common practice in only 22 percent of municipalities surveyed, and an exceptional practice in 37 percent of these municipalities. It is not practiced at all in 41 percent of the municipalities. The most common joint trench combinations place water and sewer lines in the same trench when sanitation hazards will not result; and electric and telephone lines in the same trench in various combinations with telegraph, cable TV, and other signal cables where absence of interference conditions can be assured.

Much controversy exists over whether joint trenching is advantageous or detrimental from a cost, safety, and compatibility standpoint. It is encouraged in some places and discouraged in others, and there is no clear-cut consensus of policy. Additional research is needed to resolve this question.

Effects of Lane Closures on Traffic

The opinion is widely held that lane closures for utility work in street rights-of-way have a major impact on traffic and create much congestion, delay, increased travel costs, resident inconvenience and environmental pollution.

A number of measures – limiting the amount of street to be closed at one time, restricting the hours of work to off-peak hours, etc. – have been devised to minimize these problems and are widely used. These measures, which significantly increase the cost of performing utility work in street rights-of-way, have been developed in response to public pressures and are assumed to be justified. However, there has been insufficient study to determine the costs of such lane closures or the costs of palliative measures, or to compare the two.

Some field testing performed by a number of municipalities on city streets as part of the American Public Works Association Study supports the conclusion that controlled lane closures on the majority of municipal streets during off-peak hours has a minimal effect on traffic. Additional testing would be required to determine the effects of severe lane closures on streets operating at, or near, capacity. Such testing would provide valuable information for developing optimal regulations and procedures for traffic controls at work sites. This investigation should be undertaken.

Materials and Procedures

Over the years, a number of improvements have been made in pipe, joints, cable and other materials used in utility installations. Such improvements, which increase reliability and extend the useful life of facilities, can pay dividends in reduced maintenance, and total system costs over the life of these installations. Continued product improvements should, of course, be encouraged. More economic studies, however, should be performed to determine to what extent higher first costs for improved products can be justified over the long term, using a total systems cost approach. Once determined, these analyses should be used to guide engineering practice.

Technological innovations such as the telephone *wave guide* transmission systems which greatly increase the number of messages that can be sent through limited cable space, could produce dramatic improvements in the utilities field. Procedural innovations such as direct burial of cable could also be useful. Use of plastic pipe for high-pressure gas lines can save initial costs and reduce service failures. The delivery systems of many utility systems, however, remain essentially unchanged from earlier technological eras. More research is needed, and should be undertaken, to improve these delivery systems.

The Study

The study of the assessment of the current state of the art of accommodating utilities in public street rights-of-way was begun in December, 1971. Initially, the study was undertaken under contract with the Federal Highway Administration (FHWA). In order to make possible the expansion of the scope of the study and to stimulate interest by many agencies in the project, financial support of 25 cities, 7 states, and 15 public utilities was solicited and obtained.

There were four major thrusts to the investigation. These were: a literature review: field interviews of central and suburban governmental entities, as indicated in Table 1, Field Inventory Sites; a mail questionnaire to which 222 replies were received; and a study of the effect of street openings upon traffic.

A large advisory committee was formed consisting of members of the Streets and Traffic Committee of the Institute for Municipal Engineering and representatives of engineering and utility organizations from the United States and Canada, as well as the Federal Highway Administration.

Each financial supporter designated a representative on the Project Advisory Committee – a group which also diligently reviewed the project outputs.

As a result of the study and this report on the state-of-the-art, a Manual of Improved Practice has been prepared and is being issued jointly by the American Public Works Association and the American Society of Civil Engineers (ASCE). ASCE participated actively in the review of the report and Manual of Improved Practice, and financially in support of the Manual.

This report contains nine chapters which review in detail the utility accommodation practices determined from the field and mail surveys. Although adoption of many of the practices and procedures which are highlighted have been feasible only in larger sized communities, nevertheless most can be adapted for use by smaller jurisdictions. Certainly improvement is needed by almost all agencies, and current problems should not be accepted as the norm – and unsolvable.

TABLE 1
FIELD INVENTORY SITES

	CENTRAL CITY	SUBURB
1.	Atlanta, Georgia	Decatur County
2.	Austin, Texas	---
3.	Baltimore Maryland	Baltimore County
4.	Baton Rouge, Louisiana	Baker
5.	Boston, Massachusetts	Brookline
6.	Chicago, Illinois	---
7.	Columbus, Ohio	Upper Arlington
8.	Des Moines, Iowa	Urbandale
9.	Denver, Colorado	Aurora
10.	Greensboro, North Carolina	---
11.	Jacksonville, Florida	---
12.	Kalamazoo, Michigan	Portage
13.	Minneapolis, Minnesota	Brooklyn Park
14.	Montreal, Quebec	Verdun
15.	Oakland, California	Fremont
16.	Ottawa, Ontario	---
17.	Portland, Oregon	---
18.	Phoenix, Arizona	Tempe
19.	San Diego, California	San Diego County
20.	Seattle, Washington	Bellevue
21.	Wichita, Kansas	El Dorado
22.	Winnipeg, Manitoba	---

CHAPTER II
CITY PLANNING, LEGAL AND SAFETY CONSIDERATIONS

City Planning

To understand the relationship between city planning and utility planning, it is useful to place this urban problem in historical perspective. Certain facts stand out:

1. Most communities in the United States were not planned – they just grew, the result of countless independent decisions of individuals and businesses seeking fulfillment of private goals and objectives.
2. The development patterns of most large American cities were established early in the 19th century and antedate the telephone, electric power supply, street lighting, and several other utilities common to the modern urban area.
3. Public water supply, and sewer systems and drainage systems were the first utilities to be installed in American communities and became governmentally operated enterprises; in contrast, telephone, telegraph and electric supply systems followed from inventions and private entrepreneurial efforts of people like Thomas Edison and Alexander Graham Bell and were developed as *private* or investor-owned utility services. These newer utility services were granted franchises to operate within communities, and although bound by certain restrictions, were left to plan and develop systems for the provision of their services as private entrepreneurial enterprises.
4. City planning, as it is known today, did not become a governmental function in the United States until well into the 20th century. By that time, the damage had already been done in most American cities. High density urban cores, designed for an earlier era, were ill prepared to accommodate unplanned and unpredicted traffic and an increasing complexity of utility services in narrow street rights-of-way.
5. Utility planners have generally proceeded with only minimal interface with governmental planners.
6. Environment, conservation, and aesthetics were given little consideration.

These facts help to explain the congestion of subsurface and overhead space in street rights-of-way, and the untidy system of utility networks and all the dysfunctions and problems attendant thereto. Modern city planning seeks to rationalize land uses and provide for efficient growth and the provision of the services and amenities necessary for urban living. The provision of transportation and utility networks is certainly one of the concerns in the planning process. This process includes, among others, the development of comprehensive plans and the implementation of these plans through zoning regulations, subdivision regulation, capital improvement planning and programming, urban renewal efforts and other orderly procedures. In the United States, planning is typically carried out by local and regional governmental agencies through the medium of staffs of professionals or consultants working for lay boards and commissions. Unfortunately, city planning and utilities planning are normally carried out as independent efforts by different groups – the former by governmental planning bodies, the latter by a series of investor-owned utility companies. City plans are developed – and changed – often with little regard for the effects of these decisions on utility networks; and utility facilities are installed as afterthoughts following community development. This attitude may place utilities in the position of *make do* with inadequate space in street rights-of-way which were originally planned on the basis of automobile traffic requirements and aesthetic considerations with little regard for utility plant requirements. Utility operation may be further restricted due to heavy traffic demands upon the street.

Although utility services such as electricity, telephone, gas and other privately-owned utility services are fully as essential to modern urban life as municipally-provided water, sewage, signal and transportation systems, their planning is not integrated into the community planning process. Comprehensive plans typically include a land-use plan; a plan for certain public facilities such as schools, libraries, governmental administration buildings, fire stations, police stations; a street plan and a plan for governmentally-owned water, sewage and drainage systems. Telephone, gas, electric and other privately-owned utilities are usually not included in the plan. This is a gross oversight. Both government and utilities are responsible for the lack of joint planning.

Investor-owned utilities are not only essential to urban life but their physical plants occupy a good deal of space within street rights-of-way and represent considerable capital investment. The utility networks are inextricably tied to community growth patterns and must be adjusted as conditions change. The development of a high-rise office building can require the laying of trunk facilities of several different types of utilities from substations, switching facilities or treatment facilities miles away, thus affecting not only the area in the immediate vicinity of the new development, but also the network of streets that extends for miles in several directions. Constantly torn-up streets, with attendant traffic impediments, are only one manifestation of this lack of planning and coordination.

The decisions of the planning commission, zoning board, building code officials, and street officials can significantly – and often adversely – affect utility agencies. Density changes can tax existing utility plant capabilities. The approval of *leap frog* subdivisions not adjacent to existing utility facilities can require the extension of additional utility plant, and leave utility officials with the problem of estimating the ultimate extent and timing of the loading of their facilities during the development stage. The vacation of street rights-of-ways without consideration for the utilities which are located within those rights-of-way places those utility companies in the position of having to buy back an easement or relocate their facilities. Street rights-of-way widths planned without regard to utility space needs force utilities into undesirable under-pavement locations or into overcrowded parkway areas. Unanticipated street realignments, widenings, and grade changes require the relocation of existing utility facilities which may even be relatively new. Unanticipated or unannounced street resurfacing projects can disrupt independently developed utility construction and maintenance plans or result in the cutting of newly resurfaced streets. Granting of street encroachment permits to building owners to allow them to expand basements, parking garages, vaults, stairwells, or other building appurtenances into the subsurface space beneath sidewalks or into the roadway area can preempt valuable space from the utilities needing those alignments.

The lack of integrated community and utility planning produces these and other adverse effects; it results in the loss of the opportunity to use utility planning as a positive instrument in the control and shaping of community growth. Enlightened utility management is, thus, often frustrated by the inaction of local planning and other public agencies.

Utilities have contributed to the developmental problems encountered by local government by construction practices which do not result in following established lines and grades for underground facilities, replacement or maintenance programs not timed for optimum restriction of the use of the right-of-way and, at times, a rigid desire to preserve their individual *space requirements*.

An important aspect of city planning has been the current trend to require undergrounding of utilities. Over 80 years ago in New York City, the mayor found that the growing network of electric, telephone and telegraph lines was a safety hazard as well as an eyesore and ordered the Fire Department to cut down the poles.

The major stumbling blocks to undergrounding have been the increased cost of underground plant and the difficulty in determining a measure in dollars of the benefits achieved. The costs and benefits of clearing scenic views, improving civic appearance, removing safety hazards which are a danger to motorists, eliminating obstacles to air travel, and overcoming the threat to service due to high winds and ice conditions are all but impossible to measure and allocate properly.

Since 1964, nearly half of the electric utilities have adopted a policy of undergrounding distribution facilities in new subdivisions. The Bell System has initiated a vigorous program to underground its plant. This trend has been nurtured by the reduction of the cost differential between aerial and underground construction, which is now about 1.5:1 for facilities installed in good earth and with good weather conditions. An additional stimulus to undergrounding has come from Federal programs which are a source of financing new or redevelopment projects.

Conversion of existing aerial plant appears to be the result of two efforts. In congested business areas with high visibility, potential safety hazards and lack of service potential, some utilities are programming the undergrounding of their plant for complete conversion within a set number of years. In residential areas, some cities have formed local improvement districts to finance undergrounding. Seattle, Washington, has been particularly successful with such a program.

The mail survey of 222 agencies revealed that 65 percent of the agencies required the undergrounding of investor-owned lighting, power and/or communications in certain new installations. Only 36 percent, however, required conversion of existing aerial plant. With regard to municipally-owned light, power or signal wiring, 62 percent place it underground, 15 percent do not, and 22 percent did not have such utilities. Conversion of existing aerial plant to underground is being undertaken by half of the agencies with aerial plant.

Special Undergrounding Policies

The legal basis for undergrounding is missing in many areas. Where success is being registered in eliminating overhead lines in new developments this trend is usually based on persuasion. Success is also due to a newly felt desire on the part of developers and home purchasers to clear the environment of unsightly wire networks. Many municipalities, however, have adequate legal power to support undergrounding edicts. Some examples of no-law and legal stipulations will clarify the point.

- In Baltimore, Maryland, a five-year-old Maryland law, not fully exercised by the city, permits a group of property owners in a subdivision or other unit to organize an *undergrounding district* and to obtain approval from the city council to negotiate with private utilities for such services. Payment of the differential cost of undergrounding would be assumed by the property owners in the so-called *district* or funds would be obtained via a special property tax or through sale of bonds. A state law requiring undergrounding of utility services to all new buildings is strictly enforced.
- A Massachusetts law gives permissive authority to local governments to enact ordinances requiring utility undergrounding. But Boston, like other cities, has not invoked this power because of objections from the utilities and the costs that would be imposed on property owners when conversion of existing facilities would be required by the new underground locations.
- Columbus, Ohio, has enacted no compulsory undergrounding regulation for new subdivisions and no Ohio utility laws are in effect. Considerable undergrounding is being accomplished by voluntary action and mutual negotiations between developers and private utilities.
- Des Moines, Iowa, re-amended its Municipal Code through Ordinance No. 7716, in July 1968, to adopt a comprehensive plan to guide future developments, covering all physical features of the right-of-way and utilities therein. The Code requires the undergrounding of all utilities, with the exception of power lines of nominal voltage of 15,000 volts or over. The developer must make all necessary arrangements with the utilities to meet requirements.
- Without the benefit of any undergrounding requirements, Austin, Texas, has succeeded in getting such services in 60 percent of new subdivisions.
- In Arizona, undergrounding of residential electric service became mandatory in August 1970, with the enactment of General Order U-48 by the State Corporation Commission (Public Service Commission),

which also requires the provision of all suitable right-of-way and easement requirements.

- The California Public Utility Commission, in Case 8209 in late 1967, ordained the gradual conversion of existing overhead plant to underground. The City of San Diego, in cooperation with the Pacific Telephone Company and the San Diego Gas and Electric Company, has established an underground utility conversion policy and it has recommended a six-year program for such conversions.
- In Wichita, Kansas, the Wichita-Sedgewick County Metropolitan Area Planning Commission established regulations covering all subdivisions. The regulations provide for undergrounding in all residential subdivisions of electric and telephone service, except for power lines over 12,000 volts, surface-mounted appurtenances, or where the subdivision is already served by overhead facilities.
- Greensboro, North Carolina, requires the undergrounding of utilities for group housing developments and planned unit developments. Other residential developments have the option of undergrounding or locating aerial plant on rear lot easements. In 1967, the State Utilities Commission approved an additional fee which the electric utility can charge for underground installations. This is a flat rate fee based on lot size, number of buildings and number of dwelling units. The charge places the eventual cost on those served, rather than on the utility.
- Kalamazoo, Michigan, has no legal requirements covering undergrounding, but the Michigan Public Service Commission requires undergrounding of electrical distribution systems in new residential subdivisions after January 1, 1971. Although it is not legally covered by this requirement, Michigan Bell Telephone has adopted its own policy of undergrounding all new construction where the terrain permits; it finds that it thereby achieves lower maintenance costs.
- In Winnepeg, Manitoba, no undergrounding regulations are now in effect. An old by-law requiring compulsory undergrounding was repealed.
- Montreal, Quebec, has no regulations relating to undergrounding but encourages it in new areas. One city requirement helps induce undergrounding: overhead wiring is barred in the city right-of-way and back lot or back alley locations are required for overhead plant.

Planning for Future Utility Needs

The future challenges planners and utility constructors to recognize mounting needs and to anticipate the demands on utility services in their advance planning programs. The field investigations explored the depth and dimension of such future planning goals, and the legal and fiscal constraints which have limited the ability of utilities to build future capacities into today's design and installation programs. In the absence of coordination of planning activities between municipal planning agencies and the municipal- and privately-owned utilities, independently-arrived-at projections are often used for forecasting physical plant needs.

- The utilities serving Boston, for example, practice advance planning, coupled with efforts to initiate some degree of future readiness in their present operations. Electric utility planners work on a 10-year plan, with future prognoses of demands until the year 2000. The gas utility operates on the basis of a 10-year plan. The telephone utility plans for the future by installing added ducts in its underground plant, for its own purposes as well as for city facilities such as street lighting, traffic and communication conduits. One duct must be provided for city use in all new ducting work.
- Columbus, Ohio, utilities recognize that the only solution for underground crowding in the future lies in new concepts of joint space allocations. Utilities hope for the ultimate feasibility of single-cable complexes carrying multiple utility services. The city engineer envisions utility tunnels for multiple future needs, with joint sharing of costs, if problems of interferences and hazards can be resolved by electric, telephone and other utilities.
- In Austin, Texas, each utility plans for and designs installations for future growth. A relief sewer now under construction was

designed to serve volume needs to the year 2000. The telephone utility installs vacant plastic ducts under streets before pavements are placed. Its designs cover future needs for 10 years for buried cable, 10 years for overhead plant and at least 23 years for conduit. All designs are based on growth forecasts by divisional commercial engineers. Because of possible future annexations, the city also approves utility locations and water and sewer facilities in a five-mile zone outside the city limits.

- Phoenix's future plans experience the constraint that installing extra utility capacity would become investments which cannot be recaptured by the utilities until the extra service is actually being rendered. Developers cannot be billed for the cost of oversize facilities to accommodate future consumer growth in these areas.

- The San Diego Gas and Electric Company makes an effort to anticipate growth needs by cooperating in its studies with the Urban Systems planning group of the city. The utility's advance planning, while well organized, appears to be circumscribed by economic factors. Areas must be served as they develop, but planning can proceed only as far as the individual agencies can provide definite programs. The gas and electric utility – which serves both of these basic services – is restricted by the State PUC from providing additional capacity based on speculation or *guestimates*; it can provide capacity for guaranteed development but cannot install plant in anticipation of such future development. To some extent, the future is therefore limited by the parameters established in the Master Plan, and this *futures* document can be negated by unanticipated developments and other events. In the county area, road construction through undeveloped areas must be preceded by utility location work which will eliminate the future need for tearing up highways. The need for future crossings is determined and the county installs the conduit crossings at the anticipated locations at no immediate cost to any utility; it later sells the duct space to the first applicant utility that must cross the road. If no crossings are pre-installed, the county requires boring for utility construction.

- In Kansas, growth forecasting for the telephone utility is performed by a commercial engineer in the area office in Topeka. All buried cable is designed for a 10-year growth period. All conduit construction is based on a 20-year growth period and cable in the conduit is sized to meet a five-year growth period. Restraints on unjustified oversizing are imposed by the State Corporation Commission. In the Wichita area, the Kansas Gas and Electric Company's advanced planning needs are based on a computer projection of power load requirements for a 10-year period. Five-year planning is carried out with even greater specificity. Oversizing in subdivisions is entirely financed by the gas and electric utility, subject to SCC restraints on non-revenue-producing plant. City improvements affect the utilities' installation costs, particularly if premature replacement of utilities is required because of right-of-way operations that affect the underground. Gas utility service needs are projected for a five-year period but the current general energy shortage has caused this utility to limit its specific predictions to a one-year budget.

- In Kalamazoo, all utilities include future growth predictions in their design and construction programs. This includes the public utilities. Sewers are designed for the highest land use under present zoning; water lines are designed for 20 years in the future; telephone provides one and a half lines per living unit in new residential areas.

- In Minneapolis, all future needs are provided for in current design, within the limitations of economic considerations. The Northern States Power Company is impeded by budgetary limitations; rates of growth must be predicted and sufficient funds are budgeted to enable the utility to work on a *demand for future service* concept in order to keep ahead of consumption needs. The telephone utility is limited by its expenditure budgets to what its capital expenditure program will permit it to construct for future anticipated loadings.

Legal

State laws and enabling legislation vary widely. State constitutions as well as city charters may have established relationships between government and the utilities many years before current problems were considered. Many of the franchise provisions of state and local codes were either adopted for the benefit of the utility or for the purpose of inducing a utility to provide service. Therefore, the degree of control which can be exercised by the various levels of government varies considerably.

Generally, cities have the right to grant a renewable franchise for use of the public right-of-way. Exploration of terms and condition of franchise is outside of the scope of this report. However, the local governmental agency, as the representative of the public, has the obligation to manage the use of public lands to ensure that the demands of the vehicular and utility transportation systems are met.

This obligation is usually accomplished by the granting of permits for work within the right-of-way. Issuance of a permit establishes the terms and conditions for the authorized work, permits inspection of the work to take place, and allows a record to be made of what has been done.

The right to impose conditions such as undergrounding usually is given by the state. Table 2, Authority for Utility Regulations, indicates by what authority local agencies regulate private utilities.

TABLE 2
AUTHORITY FOR UTILITY REGULATION

Authority	Percent Who Use
Franchise by State	25
Franchise by municipality	63
State legislation	21
Municipal ordinance	57
Other	4

Source: Survey of 222 agencies, 1972, by APWA

Safety

Safety standards for protection of the public and workman have been established by all levels of government. Utility associations such as the American Water Works Association, the American Gas Association and virtually all other associated groups have either established their own standards for materials of construction or have worked through the ASTM to establish industry-wide standards. In a like manner, the Federal OSHA requirements, state labor commissions and city safety codes have established standards for job-site safety.

Adherence to such codes and a general concern for safety have minimized the number of accidents in recent years. Cave-ins, sewer explosions and gas main eruptions all occur and make headlines. Such accidents, however, are seldom caused by the location of the utilities and are thus beyond the scope of this report.

There are, however, numerous utility interruptions to service due to the location of utility plant. In 1972, APWA made an informal survey of its chapters to determine the extent of the problem.

It was found that few states or communities require records to be kept of accidents and service disruptions. Experience varied widely. Akron, Ohio, reported only a few instances per year, at perhaps $20 each. Other agencies reported more extensive damage. Excerpts from several replies have been included to highlight the possible magnitude of the problem.

A. Phoenix, Arizona

Arizona Public Service Company
Gas Facilities, Year 1971

Total dig-ins in State of Arizona – 1,801

Total dig-ins in Phoenix – 80% of total or 1,711

Of the 1711 dig-ins, 80%, or 1,369, were on gas services, 20%, or 342, were on 1-1/4 in. or larger pipes.

The total cost within the city came to $154,470 for replacing broken gas services and mains.

The main reason for the dig-ins on the gas services is assumed to be due to contractors who felt it more expeditious and time-saving to break the line, place their own pipe in the ground, and then have the utility replace the broken service line. A broken line seems to get faster utility action than a request for the relocation of the service prior to the laying of the water or sewer or other types of underground pipelines. Another reason seems to be that gas services are not always shown on various types of construction plans which lead to digging without prior exploratory excavation.

City of Phoenix Water Department – Mains and Services: During the first six months of 1971, there were 88 service line breaks and 82 main breaks which were caused by contractors. This averaged out to 15 services and 14 mains per month. The total charges for the repairs amounted to $16,745. Average length of time to repair each main and restore service was two hours.

There are several reasons for these dig-ins:

1. Contractors failed to call in for line locations and proceeded at their own risk.
2. Pipes were not in location shown on plans.
3. Water utility was unable to respond to requests on a very short notice for these relocations.
4. Even though locations had been established, mains were broken. These might be assumed to be negligence on the contractors' part.

City of Phoenix Sewer Department: During the calendar year 1971 there were 71 sewer main breakages caused by excavation. The average cost per breakage was $124 and the average repair time was 2-1/2 hours. Since there are no valves to shut down in a gravity sewer, service was uninterrupted.

During the five years previous to 1971, the City Sewer Department averaged 742 tap breakages per year at an average cost of $89 each and an average repair time of 2 hours.

Mountain Bell (Telephone Company): During the 1971 year, the reported damage cases numbered 349. The cost to repair the reported damages came to $81,471. The cause of these damage incidents appeared to be the same as reported by other utilities.

As a general statement, every utility company in this area has damaged the others' underground facilities. The telephone company has broken water mains and services, sewer services and gas mains. Vice versa, the Water Department in its construction activities has broken telephone cables, gas services, etc. Therefore, the pipeline contractors are not responsible for all the dig-ins. Each utility and contractor must assume its share of the responsibility for these dig-in extra costs.

B. Central California Chapter Area

Public Agency	Underground Facility	Estimated No. of Accidents in 1971	Estimated Amount of Damage
Pacific Gas & Electric Co.	Gas-Under 2 in. pipe size	64	$5,344
Pacific Gas & Electric Co.	Gas-2 in. and larger	11	3,038
Southern California Gas Co.	Gas-Under 2 in. pipe size	45	Not Available
Southern California Gas Co.	Gas-2 in. and larger	10	Not Available
Merced City Public Works	Telephone, water, gas, cable TV	52	$500/accident
Fresno City Public Works	Water	1 per week	$20/accident

C. State of Washington

Washington Natural Gas: for King, Pierce, Thurston and South Snohamish Counties number of dig-ups caused by excavation equipment in 1971 – 1,100

Pacific Northwest Bell Statement, 1971 (1,140): In June 1971, 77 accidents occurred. Twenty-three were caused by governmental agencies and 54 by private parties. In the case of 14 of the sites requests had been made for service to locate lines.

For July 1971, there were 80 dig-ups. Fourteen were by governmental agencies and 66 by private firms. Only 23 calls for service to locate lines had been made for the accident sites.

General Telephone Co.: Snohomish County, 1971 – 150.

D. King County Washington

A representative group of 31 accidents was categorized by the primary cause, as determined by the county inspector. The causes and numbers of accidents were:

1.	Inexperience of operator	3%
2.	Utility not on expected alignment	12%
3.	Careless operator	9%
4.	Precise location not known	3%
5.	Line not lowered to proper depth prior to street-grading	9%
6.	Line too shallow	23%
7.	Unknown location	6%
8.	Defective material	3%
9.	Utility not at indicated depth	9%
10.	No cause reported	1%
11.	Unmarked line	6%
12.	Drilling, test hole	3%

E. Anne Arundel County, Maryland

Department of Public Works: During 1971 there were 13 cases of damage to underground water and sewer pipelines of the county by contractors. Of these 13 cases, 12 were sustained in the area of water and sewer lines, and damages totaled $2,893.30.

During 1971 there were 62 cases of damage to underground pipelines. Of these, 59 were sustained in the area of service connections and three were to large water mains. Little property damage resulted; however, the average cost for each of the service connections damaged was estimated to be $100 per incident. The average cost for each damage to a water line was $2,500.

CHAPTER III
PERMIT SYSTEMS

All utility facilities must have some form of governmental authorization to utilize space in, on, and over rights-of-way in public streets, highways, lanes and other public areas. This authorization is given by various types of statutes, ordinances or resolutions granted by various levels of government.

The *franchise* right to utilize right-of-way space for utility structures only rarely, however, grants uncontrolled powers to carry out work in the public ways. The general principle involved is: Franchise or other legal rights to use the right-of-way – or even the authorization to occupy such space by sufferance in the absence of any legally authorized right – is a general but not a specific stipulation. The ministerial power of local governments to control publicly owned roads and streets is not abrogated by any blanket or general right of utilities to use space in these areas. Space cannot be used without further authorization to perform specific work in the right-of-way.

The power of urban governments, superimposed on so-called franchise rights, is imposed on utilities by systems of licensing and regulation of utility accomodation, covering all forms of new construction, reconstruction and improvements, relocation and repair and emergency work for each incident or instance, as signified by the issuance of a permit for each specific purpose.

The permit system, and the requirement that utilities must base their right-of-way operations on authorizations granted by a permitting authority, is the key control mechanism for providing orderly allocations of underground and overhead space. The basic purposes of permits are:

- To register the utilities' intention to carry out work within the right-of-way, in accordance with its franchise or other legal authorizations to install and maintain plant in such public way
- To stipulate the nature and extent of such right-of-way work
- To provide an administrative means for the governmental permitting agency and other involved agencies to coordinate the use of right-of-way space, to hold the utility responsible for the authorized work and to perform necessary reviews, inspections and enforcement actions in connection with such right-of-way operations
- To grant formal approval for the intended work and to establish records of all right-of-way utility operations and plants, and to document them as part of an orderly allocation of underground and overhead space.

Right-of-way permits, issued for these purposes, relate, at least theoretically, to all types of work by all types of utility organizations vested with the right to locate their facilities in publicly-owned space. They cover pavement openings of all types, in all locations, in all types of pavement and surface conditions, and under all circumstances.

The requirement for a specific permit to perform right-of-way work applies to every entity involved in any work that will affect the public way, both privately- and publicly-owned utilities and private contractors.

In the sense involved in the current study of right-of-way utility accommodation practices, permits cover work which requires the cutting into surfaces and the substructure of roadways, streets and alleys of urban centers. They also cover work on highways and other public way areas of an interurban nature under the authority of local, Federal or state entities or other authorities having jurisdiction. Permits may not be required for the opening of any structure or device which provides entry to underground facilities – so-called manhole openings. Permits should also regulate the location of overhead utility facilities. Other obstructions in the right-of-way – such as sidewalk vaults or other non-utility structures – are normally covered by other types of regulatory statutes.

The Permitting Agency

Almost all municipal governments regulate the use of public streets and roads by utilities. In areas outside of the corporate limits of communities, and even in roads that traverse portions of cities and over which the municipal entity has no authority, the use of such rights-of-way for utility locations is rigidly regulated by towns, counties, states or Federal government agencies.

The mail survey of 222 communities found that 83 percent of the respondents had public rights-of-way within their jurisdiction that was controlled by another jurisdiction such as a county or state. All of the metropolitan core cities and satellite communities field-surveyed, without exception, regulate the use of roads and streets. In the mail survey, 89 percent reported that they regulate the use of their streets by utilities; 9 percent reported regulation of some utilities; and only 2 percent indicated that no regulation occurs. Eighty-eight percent of these communities issue permits for work within the right-of-way, utilizing the issuance of permits for pavement cuts for this control and regulation purpose.

Regulating powers must be vested in the most appropriate local governmental agency if they are to be effectively administered. It is almost a universal practice to place the responsibility for right-of-way utility accommodation in the hands of public works departments or works-related agencies.

Assignment of this municipal function to public works agencies is based on the principle that regulating powers should be vested in the unit of government which has basic responsibility for the design, construction, and maintenance of pavement subsurfaces and surfaces. It is reasonable to assume that heads of the public works agencies would, in turn, assign detailed regulation to city engineers or other chief engineering officials. Whether by executive assignment, or by the specific terms of statute, the assignee is accountable to the official or body legally responsible for the control and regulation of utility accommodation policies in the right-of-way.

The official most closely involved in roads and streets work usually becomes the permit-issuing entity in the city government structure. In the case of state, county and Federal right-of-way the assignment of permit issuance and other control and regulating measures is made to the highway agency. In county government, if a public works agency exists, the local government policy of assigning authority to such a designee is commonly followed.

Permit authority policies in central or core cities in a metropolitan area are normally followed in its satellite cities or towns. In smaller suburban communities the governmental structure is normally less complex and the public works commissioner may also be the city engineer, and the sub-assignment of regulating functions need not be followed.

Variations in this practice exist: In some cases the regulating authority is not totally vested in public works agencies and a division of right-of-way regulatory powers may be in effect in other branches of government. The most obvious division of authority may be between public works and a separate highway department in city government if such a department exists. In other cases, responsibility for regulating the use of rights-of-way for utility work is assigned to a traffic and transportation agency, particularly since every street opening has an impact on automotive and pedestrian traffic flow.

In some cases, a centralized agency is set up, in public works or some other overlying agency, to handle permit programs exclusively. In such cases the public works department is still recognized as the technical overseer of permitting policies.

The City of Baltimore, Md., vests its permitting powers in a permit section of the Bureau of Consumer Services. In Boston, Mass., right-of-way permits are issued as a joint responsbilitity of public works, traffic and parking, and in some instances, the building department. In Brookline, a Boston suburb, public works is the key permit issuing agency, but with the concurrence of the building department. In Columbus, Ohio, the city code vests permit powers in the director of public works, via the city engineer. It is significant that in that city an effort is being made by the department of safety through a change in the city code, to obtain the permitting power, in order to bolster its present control of street openings that induce hazardous traffic conditions. In the suburban community of Upper Arlington, Ohio, full permitting powers are assigned to the city engineer. This simple procedure is typical of policies in smaller communities where all public works functions are carried out by one individual, such as the city engineer.

In Des Moines, Iowa, permits are issued as a joint responsibility of traffic and transportation, public works, and the State Highway Commission on primary road extensions through the corporate limits. In Urbandale, Des Moines' suburban fringe community, the full permitting authority is again placed in the city engineer. In Atlanta, Ga., direct permitting functions are carried out by the public works department. In Austin, Texas, the city council authorizes the city manager to grant right-of-way space assignments for utilities and he, in turn, has delegated this authority to the director of public works, his appointee. The city engineer reviews all applications and recommends action to the public works director. Utility permits in Phoenix, Arizona, are issued by the city engineer after referral to the traffic engineer for determination of special traffic restrictions.

In Tempe, Ariz., the municipal code authorizes the city engineer to issue utility permits for street work, and in Mesa, Ariz., the customer service department issues permits on behalf of the public works director. In San Diego, Calif., the city engineer is the permitting authority, and he has delegated his powers to the permit engineer in the community development department to issue right-of-way work authorizations in his name. In San Diego County, the county engineer, road commission, issues all such permits.

In Greensboro, N.C., the authority to issue permits for right-of-way utility work is vested in the State Highway Commission and the city director of public works, apparently because of the number of state routes traversing the city area. In the Kalamazoo, Mich., Metropolitan Area, permitting authority is split between the City, County and State Highway Departments. This spread of permit authority is indicative of the multi-ownership of roads, streets and highways within the metro complex – a condition that should tend to increase in significance as metro areas and their traffic arteries become more complex and multi-layered in administrative and regulatory machinery. In Metropolitan Ottawa, Ontario, permits are issued by the city engineer, the regional engineer and the area municipal engineer, depending on the nature of the roads and their ownership. In the case of Federal streets, the National Capitol Commission holds permitting power. In Denver, Colo., the department of public works regulates work in city-owned rights of way, but in the case of federal interstate and state highway systems the Colorado Department of Highways holds right-of-way authority over utility operations.

In Minnesota, County and State rights-of-way may be used only for the movement of traffic. Utilities do not have a right to use the subsurface area. Other states have similar laws which limit the acquisition of right-of-way to single purposes.

Typical of the assignment of permitting authority from a legally authorized agency to a working entity, Seattle, Wash., places this power in the city engineer, as delegated by the board of public works. Montreal, Quebec, involves the department of public works, the department of public utilities, the department of roads, and the traffic department in the permit issuance procedures; but this multi-layered system is, in practice, simplified through the issuance of permits by the supervising engineer of the public works department, with the concurrence, as needed, of the other governmental agencies involved.

Multiple permitting arrangements are not always as obvious in municipal practices, yet multiple reviews prior to approvals of applications are a part of most permitting systems. One aspect of multiple permitting authority deserves reference: A trend in some areas to create utility coordinating committees, underground safety and protection groups, or bodies by any other name, for the purpose of unifying knowledge, information and techniques on utility undergroundings and the allocation and occupation of right-of-way space. Such groups, discussed in greater detail in Section VI, may be composed of representatives of privately-owned and/or publicly-owned utilities, and governmental regulatory agencies. They may be informal and voluntary in character, or they may have organizational memberships, structures and powers ordained by governmental action.

Clearances Required

Centralization of permitting authority in one agency has obvious benefits. The division of responsibility among various other agencies, even though they are involved in the accommodation of utilities in street and road rights-of-way, demonstrates the truth of the axiom, "everyone's responsibility is no one's responsibility." *For this reason, the Manual of Practice recommends single-agency authority over permits.*

However, it is obvious that no single governmental agency – even a public works department – should issue permits without consultation with other right-of-way affected agencies. If master maps or records of all existing utilities are maintained by a government agency, the status of existing utility plant locations, at least theoretically, could be checked without consultation with other agencies. Permits could be issued on the basis of firm information on any interferences with proposed utility facilities. In the absence of such overall data, and to avoid interference with contemplated public improvements, the need for consultation between the permitting agency and other entities is obvious.

Permitting agencies recognize this need. In general, present practice involves the clearance of utility applications with various governmental agencies before permits are issued. This may not apply to emergency repairs or maintenance work on existing plant, but it is standard practice for new installations, relocations and other major actions on positioning new utility facilities.

The agencies contacted to clear permit applications by the public works organizations are: sewer divisions; power departments; street lighting, traffic signal and police and fire signal systems; building agencies; flood control and drainage agencies and traffic and transportation bureaus or departments. In some cases these public utilities are all encompassed in the governmental structure of the public works department. But this does not alter the referral system; it may actually expedite the processing of application review, clearance, and the issuance of permits.

The mail survey of 222 communities indicated that the average time required to process an application, if it contains all the information essential to expedite permit issuance, is approximately three days. The time lapse can vary from over-the-counter action to a week or a month or more,. The latter time-interval applies to complex projects that require extensive and intensive reviews by many agencies.

The study brought to light varying practices and experiences. In Baltimore, the permitting agency contacts water, wastewater, lighting, highways, transit and transportation, the city's common duct system agency, police, fire, highway maintenance and Consumer Services itself.

Columbus, Ohio, follows the same general practice, as do many other local governments. The city engineer will not issue a permit until the opinions of the affected departments, bureaus and divisions have been recorded. On work involving zoning or planning matters, the appropriate public bodies are also contacted. Of course, it is the general practice of most communities to involve city councils in projects which affect government policies. In many local governmental situations, new utility projects must be cleared by formal council or board actions. In such cases, the legislative branch of government is guided by the permitting agency's opinions and that agency, in turn, depends on the concurrence of all other entities in the multi-layered review system before it certifies its approval to the council or board.

In Des Moines, Iowa, over and above contacts with specific departments, the traffic and transportation and public works departments obtain the views of a utilities committee. This unit's membership includes representatives of public works, the city manager's office, traffic and transportation, urban development, the field services administration, the city engineer's office, and public works and engineering personnel from suburban communities in the Des Moines metropolitan area. In Atlanta, however, public works does not contact other utilities prior to issuing permits unless essential information is needed from them.

In Austin, Texas, the control agency communicates with all other utilities prior to permit issuance. In addition, it contacts the so-called Space Allocation Center under the city engineer's aegis, which checks proposed work against a card index of all space allocations filed chronologically by street name. If any space conflicts are disclosed, the utilities involved are then contacted and problems are resolved before permits are issued.

In general, the examples cited are typical procedures. In other urban areas, some variations may be found. The routing of applications may be to special agencies or groups that are indigenous to specific areas. In a few cases, the routing is less formal and is replaced by informal telephone contacts between local agencies.

Usually the permitting agency does not contact privately-owned utilities for information before issuing permits. When an application has been filed with the regulatory agency it is assumed that the utilities have checked between themselves to make certain no space interferences and conflicts will result.

One aspect of application clearance should be stressed. In the smaller communities – such as suburban towns, villages and cities – the publicly-owned utilities are frequently under the direct control of one agency and one key individual. In such one-man operations there is no need for distribution of applications for approval outside the sphere of the regulatory official. Thus, such suburban communities as Brookline, Mass., Eldorado, Kansas, Urbandale, Iowa, and Upper Arlington, Ohio, operate on a self-contained basis and the public works or engineering head can clear an application promptly, even if he brings in his water and sewer men, for example, to give him an appraisal of the propriety and safety of any proposed utility work.

If a utility coordinating committee exists, such a unified agency could provide the necessary review of projects and give the authorizing agency or official an overall evaluation of the work contemplated under any application. For selected major utility projects, clearance could be consummated by a coordinating committee meeting or by phone contacts by the central office of the committee Routine projects must be processed on a daily basis.

Permits may not be granted due to the paving or repaving of streets. Many agencies make extensive efforts to have all forseeable utility work completed prior to paving and then impose a ban for other than emergency work. The mail survey of 222 communities indicated that 42 percent of the respondents had such regulations and that four years was the most often mentioned length of the ban.

Jacksonville, Fla., prohibits utility cuts in new pavements by privately-owned utilities for a period of five years except for emergency situations. Publicly-owned utilities are prohibited for two years.

Which Utilities Are Required to Obtain Permits?

Permit-issuing agencies, as a general consideration of practice, upon the receipt of applications for utility work in rights-of-way distinguish between publicly-owned utilities operated by a public agency, and privately-owned utilities, operated by non-governmental agencies. Similarly, a distinction is made between anticipated right-of-way work in the form of new installations, relocations and major improvements, and unanticipated emergency work due to failures, damages and other work that is necessary to preserve the safety and operational integrity of public services.

For planned work in the right-of-way, privately-owned utilities must obtain permits. Eighty-eight percent of the 222 communities covered by the mail survey require such permits before work is instituted. The communities covered by the on-site investigation confirmed this practice. For work, other than emergency jobs, practically all central cities and suburban communities require privately-owned utilities to obtain permits prior to the institution of work in the right-of-way. Jacksonville, Florida, is typical. A city ordinance stipulated that permits must be obtained *to disturb, excavate, block, obstruct, tamper with, or place any constructions or other material on or in any public road, right of way or easement of the city.* An innovative exception to this practice was found in San Diego, Calif. Here, by a mutually signed agreement known as the *Manual of Administrative Practices for Utility Installations* franchised and municipal utilities are not required to obtain permits from the city for installations and maintenance work which conforms to the location and construction standards in the manual.

Permits for emergency work by privately-owned utilities are not usually required. In many cases, utilities are authorized to proceed with such crash jobs without pre-processing permit applications. But after-the-fact filing of applications is usually required to give the regulatory agency the necessary information upon which to base records of right-of-way pavement cuts.

Modifications of these permitting practices are in effect in many communities. For example, Baltimore County, Md., issues an annual blanket permit to privately-owned utilities for emergency work, but the utilities are required to notify the highway bureau of their daily operations. Jacksonville, Florida, requires utilities to notify the public works department engineering division, after the emergency repairs are completed. As-built records must accompany this notification. In some cases, emergency work may go unreported, but these instances are infrequent.

The rigidity of control over privately-owned utilities generally does not apply to publicly-owned utilities, although it should. The mail survey and the on-site investigations found that only about one-half of municipal agencies required publicly-owned functions to obtain permits for their work, either of a planned or emergency nature. This results in a serious gap in records of pavement cuts and also results in the loss of analytical data on the dependability of utility services on pavement failures and other conditions – traffic safety accident background information and other fundamental facts.

Because of this potential gap, the Manual of Practice strongly urges that *all* utility work, by both privately-owned and publicly-owned utilities, be recorded via the filing of applications and the processing of permits. While the regulating agency is part of the same governmental structure as the publicly-owned utilities, and while some may rationalize that the control entity cannot control its own urban operations, this argument fails to come to grips with the significance of total records of all work in the right-of-way.

Application and Permit Forms

Applications and permits take a variety of forms. They may be numbered to preserve continuity of records, or may be on standard forms. In many cases, however, applications are submitted and may even appear on open forms authorized by the regulating agency in the form of individual letters from utilities on their own letterheads.

The application-by-letter practice is looked upon with favor by those agencies which use this procedure; others characterize this method as evidence of over-simplification and under-acceptance of government responsibility. *The Manual of Practice urges the use of city-prepared application forms as a means of standardization and uniformity. Letters of application must, in most cases, be accompanied with plans or drawings of the proposed work. Samples of standard forms and letters of application are included in Appendix A.*

Permits take the form of standard sheets, cards or other devices in most communities. In many cases permits are issued in multiple copies, with one copy for the permittee; another for the regulating agency's own records; still another for the street-highway agency to serve as an alert that a cut is to be made; another for the traffic or police unit; and any others to fulfill other avenues of distribution.

In a limited number of cases, permits are issued in the form of an annotation on letters of application. This is an example of the pyramiding of so-called over-simplification of government procedures. Between the two extremes of formal permit systems and informal certification of informal applications, various types of permit records are used.

The advantage of standard forms for utility applications and permits is that they provide a means for formally advising the applicant-permittee of the official conditions under which the proposed project must be performed. These conditions can cover the hours of work, provisions for barricading open cuts, methods for backfilling and resurfacing pavement cuts, limitation on the extent that traffic ways may be immobilized by cuts, and other provisions. These conditions also provide a means to hold the city harmless for any conditions or incidents associated with pavement opening work.

Policies and practices on permit issuance and regulating stipulations regarding right-of-way utility work vary. For example, hours of work and street obstructions are rigidly regulated in some urban areas, to seasons and times when street openings are permitted. Work in the central business district rights-of-way is discouraged by some during holiday shopping periods. Other communities prefer to withhold approval of pavement cuts for the entire winter season, except for emergency work which cannot be postponed. Some communities prohibit or rigidly regulate street openings during scheduled community celebrations, special events or sports events.

A general practice is to prohibit street cuts in roadways which have been recently constructed and surfaced; the period of such non-cutting varies from a few months to one and even two or more years. In an effort to discourage cuts in newly paved streets, and to catalyze advance planning of utility installations in street areas which are scheduled agencies, penalties are imposed on utilities which find it necessary to cut into newly surfaced streets and roads. The price level of these penalties varies from community to community.

The regulating agency may establish policies whereby pavement cuts across major streets are not allowed and only tunneling, jacking or boring is permitted. Although costly, the lack of conflict with traffic can be an important consideration.

Fees, Bonds or Other Surety Provisions

A wide divergence exists in local governmental policies covering permit fees. The practice of posting bonds or deposits to guarantee the quality of pavement cut restoration and to hold the permitting government harmless for any circumstances relating to right-of-way work by privately-owned utilities, contractors, plumbers or drainlayers, property owners and others also varies.

A common practice is to not require specific permit fees of privately owned utilities for each right-of-way project. The general assumption is that these duly accredited utilities should be granted pavement cut privileges without the necessity of filing the type of minimal fees charged for such applicants as contractors, plumbers and drainlayers and other miscellaneous permittees. If contractors are engaged by privately-owned utilities to perform their right-of-way work, which is a general practice, such contractors are treated the same as the utilities.

The mail survey of permit practices showed that 49 percent require privately-owned utility companies to pay a permit fee and 50 percent do not; one percent reported that no clear-cut policy exists. The assessing of permit fees to private contractors is a more common practice; 69 percent of the permitting agencies charge such fees, 28 percent do not, and 3 percent reported no specific policy.

The on-site study disclosed that the general policy is to make no charge for permits to privately-owned utility companies but to require payment of fees by contractors, drainlayers and plumbers. In practically all cases, the fees are small and seldom cover the actual cost of administering the permit system. When major amounts are assessed, they are frequently tied to the cost of replacing pavement cuts, as described in Chapter IV. In some cases, the permit fee is imposed to cover inspection costs, as discussed in Chapter V.

Charging of fees for permit applications is justified by advocates of the principle that governmental services of this nature should be self-sustaining. However, the fees charged are seldom adequate to make them self-supporting. On the other hand, those who advocate no fee arrangements argue that such regulatory services should be part of the municipalities' ministerial responsibility and not assessable against those who legitimately use the right-of way to render public service. In addition, utilities have argued that their taxes should support the service. Requirements for permit deposits to assure proper pavement restoration is readily defended and seldom criticized.

The requirement that permittees file bonds with the regulating agency is based on a need for assurance that work in the right-of-way will be performed in full compliance with governmental requirements and any provisions covered by the specific permit issuance. The mail survey showed a difference in policies relating to privately-owned utility companies and contractors. No bonding is required for utilities in two-thirds of reporting agencies; one third require companies to post bonds in various sums, covering individual or total yearly periods. For private contractors, bonding is required in approximately 70 percent of the surveyed communities. These bonds, by utilities and contractors may cover each specific project – 46 percent – or year-round operations – 75 percent.

The field studies disclosed varying bonding practices. Bonding of individual projects was cited as varying from small amounts to $5,000 or higher, depending on the nature of the project and the amount of right-of-way work involved. Bonds are held in escrow and returnable upon completion of the work and expiration of any designated performance-time stipulations. Total annual bonding, or continuing bonding, can carry a high price too – as much as several million dollars in the case of utilities which carry out extensive right-of-way work involving major pavement areas. In many cases, no bonding is required of privately-owned utilities, again because of their corporate integrity and reputation for adherence with local codes and standards. Escrow accounts may also be used. Fees and charges may be deducted before returning the deposited funds.

Jacksonville, Fla., makes no charges for permits to utilities but private contractors must post bonds in compliance with a city ordinance. Denver, Colo., requires no bonding by privately-owned utilities but private contractors must post annual bonds for right-of-way work. The bonding fees are established in an official bulletin which displays the type of approved bond.

Baltimore, Md., makes no charge for permits to privately-owned utilities, private contractors, plumbers or drainlayers. Plumbers and drainlayers, however, must place money in escrow to cover the standard cost of cut replacement, $30 per square yard. Contractors who work for the utilities do not post guarantees but when they operate for themselves, deposits are required. Brookline, Mass., makes no fee charges for permits but requires privately-owned utilities and their contractors to post bonds of $5,000 per project, to be held on deposit until the work is completed, inspected and approved.

Seattle, Wash., requires private contractors to post assurance bonds. Ottawa, Ontario, charges a permit fee of $10 per 100 linear feet of trench excavation and $5 for each additional 50 feet. For trenches exceeding 30 feet in depth and exceeding 12 feet in width, an additional $10 is charged for the first 100 feet of trench and $3 for each additional 50 feet. Utility pole installation permits are issued for a fee of $10 per block face. Private contractors and privately-owned utilities must file bonds to meet the official requirement that "No person shall receive a street cut permit or a trench excavation permit without proof of non-deductible insurance for three months in amount of not less than $50,000 for any one claim and $100,000 for more than one claim on account of public liability for any one accident and in an amount of not less than $10,000 for any one accident for property damage." In addition, a security of $1,000 is required to guarantee that the street is left in a proper state of repair. This bond requirement covers up to 10 permits.

Boston, Mass., imposes no permit fees on privately-owned utilities but the companies provide hold-harmless provisions to the city by filing bonds to assure payment of costs for trench replacement and repaving in accordance with city standards. Private contractors and drainlayers post bonds. Urbandale, Iowa, exempts privately-owned utilities from payment of permit fees or posting bonds, but contractors pay permit fees of $3 for cut work outside of pavement areas and $5 for pavement cuts. Contractors and plumbers post $200 in bonds, in certified checks or cash for each job. These are held in escrow for four years to assure proper cut restoration work. The State Highway Commission at Greensboro, N.C., requires bonding by private contractors.

San Diego, Calif., offers a variation in permit charges and bonding practices. Privately-owned utilities, with the exception of those which have exclusive franchises (gas, electric and telephone), are required to obtain encroachment permits. Contractors working for them in areas outside of those covered by the exclusive franchise provisions must file bonds. Kalamazoo, Mich., requires privately-owned utilities to post $25,000 indemnity bonds and the County Road Commission and the State Highway Department may require privately-owned utilities and contractors to post performance bonds prior to the issuance of permits .

Des Moines, Iowa, provides an insight into how water utilities, which are set up as independent water boards, commissions or other entities, are covered by right-of-way permitting practices. The Des Moines Water Board is not required to pay permit fees. This parallels the procedures used by the city for privately-owned utilities. Bonds are not required from the water utility, in keeping with similar no-bonding requirements for privately-owned utilities. Thus, the water utility is handled in the same manner as though it were a privately-owned utility, which, in fact, it is in the Des Moines governmental structure.

The crafts which handle building connections to public water and sewer utilities normally require rigid inspection in all phases of their operations. In some areas licensed plumbers are authorized to make such connections; in other regions the term *plumber* is not used for this craft and the licensed or certified practitioners are called *drainlayers.* This latter nomenclature is prevalent in the New England area. They are licensed by either state or local agencies, such as plumbing boards. Only those so certified can make water and sewer connections and work in the right-of-way for this purpose, over and above being regulated for plumbing and drainage work within building lines.

As defined in the above discussions of application and permit practices, plumbers and drainlayers are subject to even more rigid requirements than those imposed on utility firms and contractors who work for them. If permit fees are imposed, they are required to pay. If bonding is required, plumbers and drainlayers are required to post such guarantees. In fact, some municipal regulating agencies stipulate bonds, certified check deposits or cash escrow funds even if other permittees are not required to make such protective funds available to city government.

Such regulation by the local agency is often not provided for other utility connections such as underground electrical connections, where the work is oftentimes performed by the employees of the land developer. Such work should also receive inspection and licensing by the public agency.

Record of Permits

At the heart of the permitting system is the maintenance of records of all the right-of-way operations of all utilities, both publicly- and privately-owned, and of others working in the right-of-way. This is the reason why advocates of application-permit practices covering public utilities are so insistent that failure to issue formal permits for water and sewer work, as well as for other publicly-owned utilities such as street-lighting, traffic light cables and police and fire signal systems, destroys the integrity of right-of-way records. A complete record of all such facilities in one place is desirable to avoid future conflicts in use of street rights-of-way.

Most Agencies make efforts to maintain records of all permits issued, together with more or less complete documentations of as-installed utility facilities. The mail survey disclosed that, of the 222 respondents, 75 percent of permitting agencies maintain such records. There is no indicated uniformity or standardization of the methods of record-keeping. Some agencies merely file copies of the permits under various means of classification – street, names of utilities, etc. Other agencies utilize separate record forms, other than the permit form itself, to document right-of-way pavement work. Others transfer permit records on a daily or periodic basis into chronological file books, categorized by streets, city ward or zone areas or other means for the orderly recording of such work. Some agencies microfilm permit records.

Oakland, Calif., maintains records by filing the original copies of permit forms in the construction division of the Department of Public Works. In Fremont, Calif., records are maintained in the Encroachment Permit Section of the city engineer's office. In Montreal, the road department issues permits in duplicate. The originals are filed permanently and the copy which goes to the permittee is returned to the department upon completion of the job, where it becomes a record in the street construction section. This record serves as notification that the cut is ready for resurfacing. Des Moines' permits are filed by street location and by number sequence and the files are retained for at least five years. Records by street and address are maintained in books, with the pages microfilmed since 1955.

At Austin, Texas, all space allocation assignments are listed chronologically on card files, indexed by street name, in the engineering department and the street maintenance division of the public works department. They are cross-referenced to plans and drawings when these records are available. Kalamazoo maintains its permit records for three to four years before being retired or destroyed. Boston microfilms its permit records for convenience in filing.

In San Diego, due to franchised utilities being exempted from obtaining permits, utility record maps are maintained by each utility. The city maintains only sewer and water system record maps plus a file of permits issued to non-exempt utilities. The city engineer in Phoenix, Ariz., maintains file copies of all permit drawings including as-built records, and utilities maintain separate record maps. However, recognizing the need for one coordinated set of record maps, they have begun development of a digitized data base system on a demand readout basis. When operative, this system can produce a computer drawn plan of facilities at any location upon demand and thus eliminate the need for a physical mapping system.

Traffic Control Requirements for Utility Work

One of the reasons for regulation of the right-of-way of urban areas is to assure the dependability and safety of automotive traffic flow and pedestrian movement. For this reason, permits are issued with stipulations concerning the seasons, days and hours of utility work, the extent of cut openings in one or more traffic lanes, the closing of open cuts with timber or steel plate bridging to expedite traffic during non-working periods, the method of barricading obstructions in the public way and the safety signs and warning lights that must be installed.

Traffic regulations are normally adopted by formal action of the legislative body, or they are issued by edict of the appropriate agency. These regulations are usually issued in the form of booklets or guidebooks which list rules and procedures and portray the types of required barricades, signs, warning lights and any other traffic control and safety devices to be used. One additional practice of a specific community deserves further commentary. San Diego, Calif., in its *Manual of Administrative Practices for Utility Installations in Public Rights-of-Way,* outlines safety and control procedures of special pertinence. It sounds the keynote as follows: "The Utility working in the street shall be responsible for the safe movement of traffic through the construction and maintenance operations. Signs, warning devices and general conditions of safety shall be as detailed in the 1966 edition of the San Diego and Imperial Counties Chapter of the American Public Works Association Traffic Control Manual." With certain exceptions, it continues: "However, insofar as any signatory to this manual is governed by the Williams-Steiger Occupational and Health Act of 1970 (29 U.S.C.A. 650 et seq.), said provisions or any regulations issued pursuant thereto shall apply to said signatory in lieu of those set forth above."

The National Committee on Uniform Safety Control Devices published a revised manual in 1971. Under Federal law the provisions of the manual apply to *all* roads and streets.

Appendix B of this report includes a sample of traffic regulations in a typical city.

Because of the effect of street openings on the flow of automotive traffic, this study conducted detailed analysis in several representative urban areas to ascertain the relationship between obstructions in the pavement and the movement of automobile traffic. The studies were carried out by qualified local traffic engineering personnel, in accordance with carefully detailed specifications. The findings were revealing: they demonstrated that, with carefully regulated right-of-way work, the time-loss due to obstruction averaged only between eight and ten seconds per vehicle per incident. The study is described in Chapter IX.

An effort has been made to determine the average time of lane closures due to various classes of utility work. Such averages are shown in Table 3, Reported Average Lane Closure Times for Various Classes of Work. While the information on this subject is admittedly incomplete, the following partial tabulation of some of the communities studied during the field investigations is of value.

TABLE 3

REPORTED AVERAGE LANE CLOSURE TIMES FOR VARIOUS CLASSES OF WORK

Utility Operation	Lane closure times (days)*
Sewer main breaks	1/2-2
Building sewer connections	1 1/2
Water main breaks	1/8-1
Water service connections	1/2-1
Water service renewals	3
Gas service connections	1/2-1
Electrical system repair	1/3
Electrical service connections	1/2
Telephone system repair	1
Storm catch basin repair	1
Steam Distribution system repairs	3-4

* All lane closure times noted are average figures. Actual closure time depends on the extent of the repair required and may exceed the times indicated. On the average, the number of lanes of traffic closed for utility repairs is reported as one lane. Actual closures, however, are subject to the scope and extent of the repair and the location of the utility in the right-of-way.

Source: APWA Survey of Communities, 1972-1973.

CHAPTER IV
OPENING AND RESTORATION OF PAVEMENT CUTS

The opening of pavement cuts, and their restoration, must be carried out in accordance with proper methods, as stipulated by regulating agencies. The closing of these pavement cuts and excavations, including proper backfill methods and materials, and temporary and permanent replacement of pavement surfaces, must be clearly specified and rigidly enforced. Every pavement opening permit presupposes that the opening must be closed and the right-of-way restored to its original condition. During the period of opening, the excavation must be properly controlled and protected to assure minimal traffic impedence and the safety of surface travel. Openings must be made in locations and in such manner as will avoid interference with already existing underground utility facilities.

Specifications for backfilling must be carefully prepared and in conformity with principles of soil mechanics. The required degree of compaction is a function of the type of material. The method to achieve compaction is also important. The soil should not be loosened or its density actually decreased by the method used.

Who Makes Utility Cuts?

There are some instances where the street maintenance department or bureau will participate in the pavement cut operation. This, however, would be done for the protection of street facilities rather than to aid the utility or share its responsibility. For example, Urbandale, Ohio, saw-cuts all right-of-way openings and bills the permittee for this service.

Privately-owned utilities generally perform cuts and trench work themselves, with their own forces, or they may use private contractors. The surveys disclosed varying utility policies, depending on their own evaluation of comparative costs and the availability of crews to do right-of-way work. However, invariably the utilities perform the actual work on their underground plant with their own trained personnel. For example, gas companies may use contractors for trenching but actual gas main and auxiliary appurtenant gas regulation devices are installed, repaired and replaced by trained gas men.

Who Backfills Trenches and Restores Pavements?

What has been said about pavement cuts and trenching applies equally to the backfilling of excavations after the work has been performed. The permit agency or other governmental units do not assume responsibility for the work of restoring trench cuts and providing any temporary replacement of pavement surfaces on projects involving private utilities. The mail survey bore out this generalized work-responsibility statement. A composite evaluation of response data showed that none made pavement cuts for privately-owned utilities; only two percent participated in any part of trench excavation or backfill; 93 percent of all temporary pavement restoration is performed by the utility; and 86 percent of the maintenance of temporary pavement restoration before permanent surface restoration is completed is performed by the utilities. The practice in making permanent pavement restoration is at variance with the principle of non-participation by city forces. The mail survey indicated that 36 percent of surface cuts are permanently restored by the municipalities – a service for which charges are normally made to the permittee.

Street cuts made by city-owned utilities are, of course, handled by municipal agencies, either with their own forces or by means of contractors retained for this specific purpose. The mail survey disclosed the division of responsibility for right-of-way cuts and restoration work on municipal utility projects between so-called "street departments" and "utility departments:" Pavement cuts – 73 percent by public utility units and 27 percent by street agencies; trench backfill – similar percentages; temporary pavement restoration – 47 percent by street departments and 53 percent by utility departments; maintenance of temporary pavement – 63 percent by street forces and the balance by utility crews; permanent restoration of pavements – 83 percent by street crews and the smaller percentage by utility forces.

The mail survey provided an insight into how municipalities bill privately-owned utility permittees for permanent trench resurfacing. Eighteen percent of the municipalities reported that they bill at cost; 51 percent base charges on established and publicly announced prices per unit area of surface replaced; a few communities reported that this service is performed at no cost, possibly because a previous or "hidden" charge has been made during the issuance of permits. Permanent resurfacing of areas opened by utilities for their own private service purposes should be performed at no cost to the municipality. In some cases, the charge includes future maintenance cost of the resurfaced area and in other cases, the utility is filled for subsequent maintenance within some limited period.

Method of Backfilling

Reference must be made to the rare instances where backfilling is carried out by the municipality – a minority circumstance in the national practice scene – and to the motivation therefor. The reason for city intervention in a practice which is in most cases a responsibility of the permittee-utility is all too clear: improper backfill methods can result in eventual failure of the underground utility, produce need for later reopening of the trench at such points, and produce unstable surface paving conditions which will result in road depressions and progressive failure of the entire street or road surface. In such cases, a municipality may choose to perform backfilling itself rather than using the procedure of enforcing workmanlike trench restoration operations by the utility.

This may be the rationale behind the Procedures for Street Excavations of Des Moines, Iowa. This code of practice states that: "The work of refilling any opening, trench or excavation in any paved street, highway, avenue, or alley, replacing the pavement and restoring the same in proper condition, and refilling any opening or excavation in any unpaved street, highway, avenue, or alley ordered by the City Council to be paved shall be done by the Department of Public Works . . . . The applicant shall pay to the City of Des Moines all costs incurred in this operation for the full amount of labor, material, and equipment, plus ten (10) percent for incidentals. The Director of Public Works may, at his discretion, permit in writing, any person authorized to make excavations in the street to refill such excavation and restore the street, pavement, sidewalk, or curb under such rules and regulations as he may prescribe."

This do-it-by-the-city procedure is preceded in the city code by reference to "refusal to issue" a permit for street openings to any former permit holder "who has intentionally violated the provisions, or the Code of 1954" relating to excavations. This official commentary may explain why the city undertakes to handle backfill operations itself.

East Kildonan, a community which has been taken into Winnipeg, estimated that over a pavement's lifetime about one-half of the capital costs of street construction were required to repair settlements, due to poor construction and backfilling practices by utilities.

Replies to the mail questionnaire indicated that for privately-owned utilities, the various elements of work were performed as indicated:

Item	Local Agency (%)	Utility (%)
a make cut	0	100
b trench backfill	2	99
c temporary pavement restoration	10	93
d maintenance of temporary restoration	17	80
e permanent pavement restoration	36	71

In contrast, where the municipal-owned utility was involved, the work distribution was as follows:

Item	Street Dept. (%)	Utility (%)
a make cut	28	73
b trench backfill	28	72
c temporary pavement restoration	47	56
d maintenance of temporary restoration	63	41
e permanent pavement restoration	83	21

Not all municipal permitting agencies have prepared specifications for proper backfilling operations, but there are many examples of good practice in the United States and Canada. The City of Montreal, for example, has issued "Requirements Concerning the Opening and Backfilling of Excavations in the Public Domain," in conformity with its By-Law 3190, which specifies sheeting and bracing, earth platforms, backfilling materials, backfilling methods, compaction and pavement restoration. It stipulates how and when backfilling can be performed with natural soils, stone screening and crushed stone, and how compaction must be carried out to attain 95 percent maximum density. Examples of construction standards are contained in Appendix C of this report.

National policies with regard to the extent of surface pavement restoration after a right-of-way cut has been made were disclosed, at least in general context, by the mail survey. It indicated that approximately one-fifth of the communities require permanent pavement restoration for the trench area only; three-quarters require the surfacing of the trench opening, plus a limited area around the cut section; and ten percent require the repaving of an entire slab encompassing the trench cut, to the nearest joints. The effective lapping of the new surface with the existing surface will enhance the esthetic appearance of the restored street or roadway, improve the riding qualities of the roadway and eliminate points of entry of ice and water.

Other facets of trench backfilling and surface restoration were clarified during the on-site investigation.

Urbandale, Iowa, where openings are made by the City, by means of sawcut operations, permits the utilities to make full and final permanent pavement replacements. A four-year ban on opening new pavements is invoked, with penalties for any disturbance of roadways during this period.

Montreal requires utilities to post bonds to assure proper cut restorations; the gas utility is reported to be bonded for $2 million because of its preponderance of cut permits. The other utilities – Hydro Quebec, the electrical utility, telephone and cable television are bonded in amounts up to $250,000. A five-year ban on pavement cuts in new surfaces is strictly enforced, with a 200-percent penalty imposed for any cuts made for any purpose within that period.

Columbus, Ohio, requires utilities to replace pavement cuts with permanent surfacing, without city intervention. Here, too, the preponderance of right-of-way cuts is made by the gas utility – 3,700 to 4,000 cut permits per year.

Boston places permanent paving over all cuts, but instead of using city forces for this work it employs a contractor. Brookline, Mass., uses a novel practice for cut restoration. The city has negotiated an annual contract with a road construction company, by formal bidding, to replace cuts and perform related work at specified prices. The contractor, rather than the city, negotiates payments for its services from the utilities, thus leaving the city out of any disputes over charges.

In Baltimore, permanent resurfacing is carried out by the permittee. If the city performs this work it charges the utilities at the rate of approximately $30 per square yard. Of approximately 2,400 private utility cuts per year, 2,000 are made by the gas utility. Water cuts for 1970 amounted to 2,100, reportedly covering city main work and water connection for building service.

Attention must be brought to "A Model Street Opening Ordinance," for regulating and controlling openings in municipal streets, prepared by the Institute of Local Government, Graduate School of Public and International Affairs, University of

Pittsburgh, in cooperation with the research committee of the Western Pennsylvania Chapter of the American Public Works Association, in 1963. In its discussion of "Restoration of the Street Opening," the Model Ordinance rationale stated that: "Although the permittee must make the pavement cut and do the necessary backfilling according to municipal specifications, the "model" vests in the political subdivision the responsibility for permanently restoring the opening. In most instances, the advantages to such a method of operation outweigh the disadvantages, particularly in larger governmental units . . . . For the smaller governmental units who do not have full-time experienced maintenance road crews or who believe that their personnel are not able to make the necessary restorations, the ordinance suggests an alternative arrangement whereby the permittee is required to restore the opening in conformity with municipal specifications . . . "

A similar "Model Excavation Ordinance" is available from the Southern California Chapter of APWA. This publication was prepared by the Uniform Ordinance and Practice Committees of the Chapter in 1959, updated in 1962, and is being revised again in 1974.

Policies on Trench and Surface Restoration

Baltimore has documented its excavation and backfill standards with representative sketches and a document entitled "Construction Notes and Requirements." The specifications cover: street cuts and repairs for rigid pavements; street cuts and repairs for full-depth flexible pavements; cuts and repairs for flexible surfaces and rigid pavements; steel plate coverings of cuts and other features. The Baltimore construction standards are typical of many other urban areas, in that they parallel state highway department criteria but they are independent documents. Utilities are authorized to make full restoration of cuts but if they elect to have the city make permanent paving, they pay at the rate of $30 per square yard. Plumbers and drainlayers pay a cash deposit to assure proper restoration.

Boston has issued a series of "Standard Details" covering excavation and restoration practices. These engineering division criteria cover major streets, residential streets, private ways open to public travel, for privately-owned utilities and water and sewer conduits. Massachusetts' highway agency has issued a "Utility Accommodation Policy" in accordance with Federal Department of Transportation Procedure Memo No. 30-4.1. The informal comments from utilities indicate that state requirements are more demanding than municipal rules and regulations. The state requires utility permittees to repave their cuts and stipulates the boring or tunneling of facilities under highways in order to avoid traffic-impeding cuts. Boston requires permittees to backfill by compacting material in 6-inch layers and to place at least two inches of temporary paving over the cut. Permanent paving is installed for the city by a contractor at prices that range from $2.19 to $2.36 per square foot, (1972 prices) depending on the areas of the city involved. Cuts in new pavements are banned for five years and permits are issued only after proof of serious need.

In Brookline, Mass., the city issues annual contracts for surface replacement; the 1972 price averaged $10.50 per square yard, covering removal of temporary filling, placing an 8-inch gravel base and covering it with a 4 1/2-inch bituminous surface.

The Atlanta procedure for resurfacing cuts differs from most cities. The permittee places an 8-inch concrete shelf-slab base and covers it with a steel plate until cured. Public works crews then install a permanent asphalt wearing surface. The Atlanta Code, section 29-62, sets a charge of $10 per square yard for resurfacing, $25 per ton for asphalt and 45 cents per square yard for heater planning. The city reports that experience with surfaces replaced by private contractors has been unsatisfactory. Each utility has adopted its own trench safety standards and a city manual dictates safety procedures for city utility work. Daytime work is limited to the hours from 9:30 a.m. to 3:30 p.m. on main thorofares and work is prohibited on such streets during Christmas holiday seasons.

Austin, Tex., sometimes requires the use of weak cement slurry backfill for the upper 12 inches of telephone, gas and electric trenches. The usual method is tamping backfill to 90-percent compaction. If trenches settle after the city has repaved, city forces retop the trench area and charge the permittee for the service. Resurfacing is generally performed within 24 hours after backfill is completed. The city uses state highway soil testing procedures on all contract work. When the city replaces surface areas it charges the utility at cost plus one-third overhead. Street work is billed to city utility departments – water and sewers, etc. – at cost. Austin tried a policy of restricting cuts in new pavement for periods from two to five years, but the practice has been discontinued.

Phoenix, Ariz., requires permittees to maintain their trenches and resurfacing for a one-year period. Backfill consists of three grades of granular and gravelly material; jetting or flooding of backfill is sometimes used. The street maintenance department permanently resurfaces cuts made by the water and sewer departments and bills the departments on an actual cost basis. An agreement with the Arizona State Highway Department provides for city maintenance of state highways. While no-cut provisions are in effect for new pavements, permits are not denied for emergency work, services to new buildings or other essential purposes. No penalties are imposed.

Tempe, Ariz., requires privately-owned utilities to maintain their cut restorations for at least one year. Backfill compaction must exceed 95 percent for the top two feet and 90 percent below that level; backfill must be tested and certified by a private soil testing laboratory.

Utilities in San Diego resurface their own trenches, in accordance with the Manual of Administrative Practices and City Standard Specifications. The manual allows two resurfacing options, covering both bituminous concrete and Portland cement paving. Hour restrictions on trench work are intended to keep traffic flowing during peak hours and peak traffic seasons. The manual is contained as Appendix F of this report.

One innovation in Wichita, Kans., practice involves the use of steel reinforcing in paving cut restoration work, in lieu of guaranteeing the compaction of the backfill. The pavement is overcut by one foot and thus the excavation is bridged. Utilities which replace paving permanently must contract with a licensed paving contractor and guarantee to maintain the resurfaced cut for a ten-year period. The gas service company has characterized the Federal Department of Transportation and OSHA requirements as more restrictive than the city standards but predicted that such regulations would eventually apply to all utility activities. The gas utility assigns contractors to replace its excavations and surface trench area and withholds 10 percent of the contract price until the city's requirements are satisfied. In El Dorado, Kans. the city can elect to resurface cuts or hold the utility responsible for such permanent restoration work.

Kalamazoo, Mich., requires saw-cutting of both concrete and asphalt pavements and the city places permanent surfaces at a cost to the permittee of $1.75 to $3.25 per square foot, depending on the type of pavement. City forces carry out repaving on all standard cuts of three feet by four feet, but contractors may be used on large restoration jobs. Rigid traffic and safety regulations are enforced.

Minneapolis provides privately-owned utilities with considerable flexibility as to cut-making and restoration but the quality of the work is held inviolate. Traffic and safety regulations, however, are rigidly established under details outlined in "The Minneapolis Work Area Traffic Control" manual.

Denver performs surface restoration work or may require utilities, including city utilities, to carry out the total backfill-resurfacing job. The division of operations of the public works department performs 20 to 30 percent of resurfacing for the water department; 100 percent for the steam and gas utilities; and only 10 to 15 percent for the electric utility. While the city does not appear to be satisfied with the work performed by private contractors, the privately-owned utilities use such forces and assume responsibility for the effectiveness of their work. Charges for city work on resurfacing are imposed on the permittees on the basis of an established fixed unit schedule.

Oakland, Calif., experience indicates that street resurfacing is required twice as frequently on areas where cuts have been made and restored than on streets where no utility cuts have been made. While some municipal agencies believe that utility cuts, properly replaced, do not shorten the effective life of pavements, a majority of respondees to the mail survey and of the officials interviewed during the field investigation tend to feel that the pavement's life span is affected by such work. This explains why the vast majority of communities attempt to ban cuts in recently installed road structures.

Montreal requires private utilities to place a temporary cold patch surface on trench cuts and it replaces this material with permanent surface material. One exception is made with the gas utility because of the extensive nature of trenching for pipe-laying or replacement service incident to the upgrading of old gas lines with plastic liners of new plastic pipe and conversion of low-pressure service to high pressure. For trench cuts over 1,000 feet in length, the utility is permitted to make permanent replacement; the utility prefers this procedure and claims it saves them money.

Baton Rouge, La., requires permittees to place temporary surfaces and maintain them for 30 days, whereafter the city places the permanent surface. While utilities pay no fees for permits if they are expected to make fill and final surface restoration, a fee of $10 is imposed when it is known that the city will be involved in permanent resurfacing and a charge of $2 per square foot is made by the city for this service. Jacksonville, Fla., follows the practice of making permanent surface restoration after the permittee has backfilled and brought the cut up to grade with temporary patching material.

Columbus, Ohio, performs no permanent surface work unless the permittee fails to carry out this work satisfactorily. In such cases, the city bills for this service. As often happens in suburban communities, Upper Arlington follows the same cut restoration as Columbus.

Verdun, Quebec, utility right-of-way practices offer another insight into problems involving underground maintenance. The gas utility has been engaged in an intensive program of servicing of old mains and protection against failures and leaks. Its crews make hundreds of bore holes and bar holes in pavement surfaces in locating such leaks and ascertaining freedom from such hazards. The city has recently established a policy of requiring this utility to seal these holes to prevent the entry of water, snow and ice and the damage to pavement foundations. A study has been made of the effectiveness of mastic plugs which can be inserted in bore holes and bar holes and pounded into place to effect tight seals. Many such probe holes are left open in other communities; the Verdun procedure deserves consideration in such areas.

Figure 1, Temporary Pavement Restoration, contains photographs of observed poor conditions. Figure 2, Permanent Pavement Restoration, contains photographs of observed poor work where there was settling of the fill material.

Additional control and regulation of right-of-way cuts is evolving from poor backfill and temporary surfaces for trenches cut by privately-owned utilities, contractors, plumbers and drainlayers. In smaller cities poor workmanship can generally be readily identified with the specific permittee and responsibility for correction can be placed with the offending utility. In larger cities, where the proliferation of underground utilities and of permits to carry out right-of-way excavations makes positive identification of the offending utility more difficult, some communities are requiring permittees to identify their own trench replacements by means of color coding circles, squares or other designs. Specific color and shape codes are assigned to each utility and they must mark the pavement at trenches which have been restored with temporary

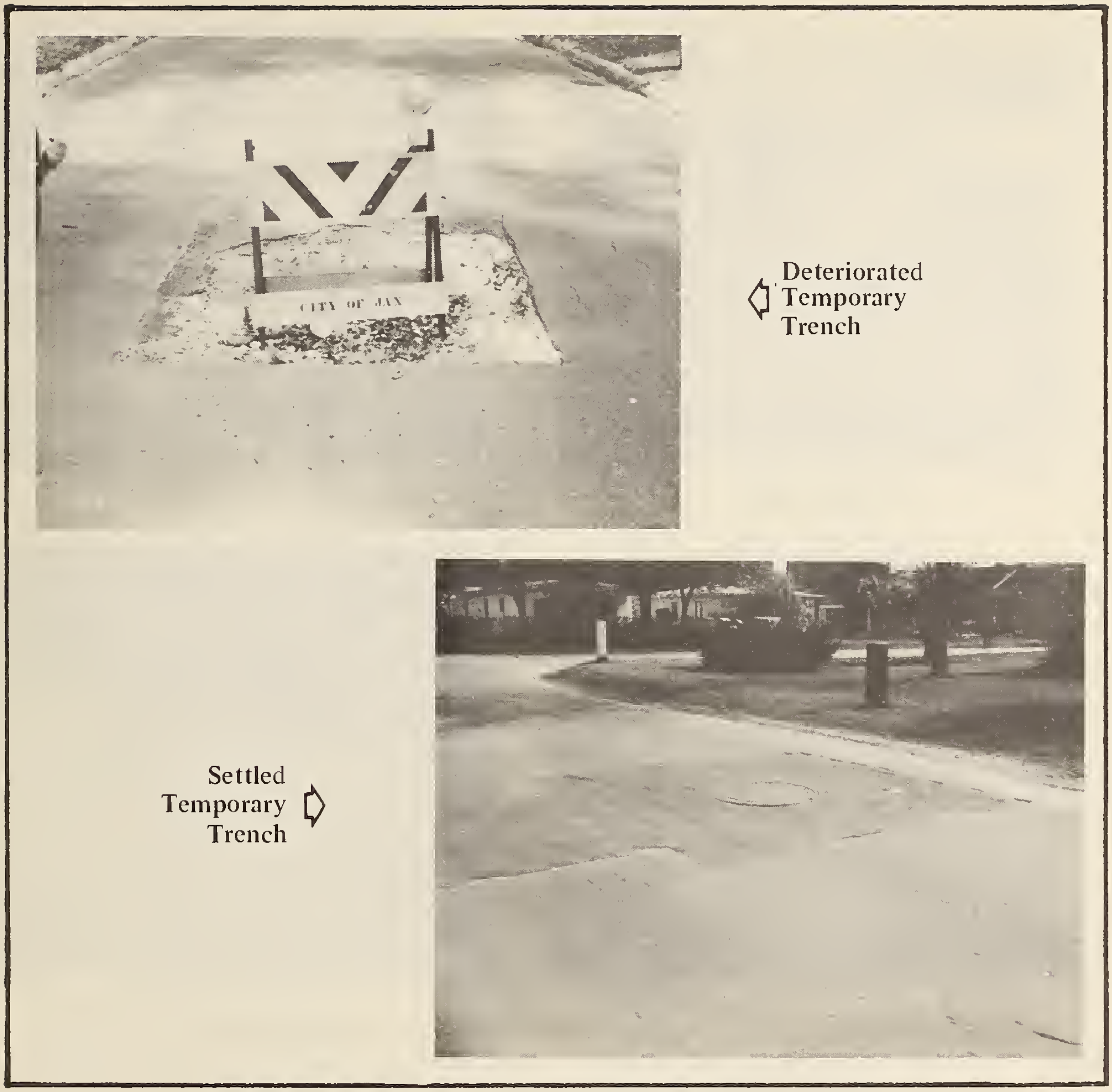


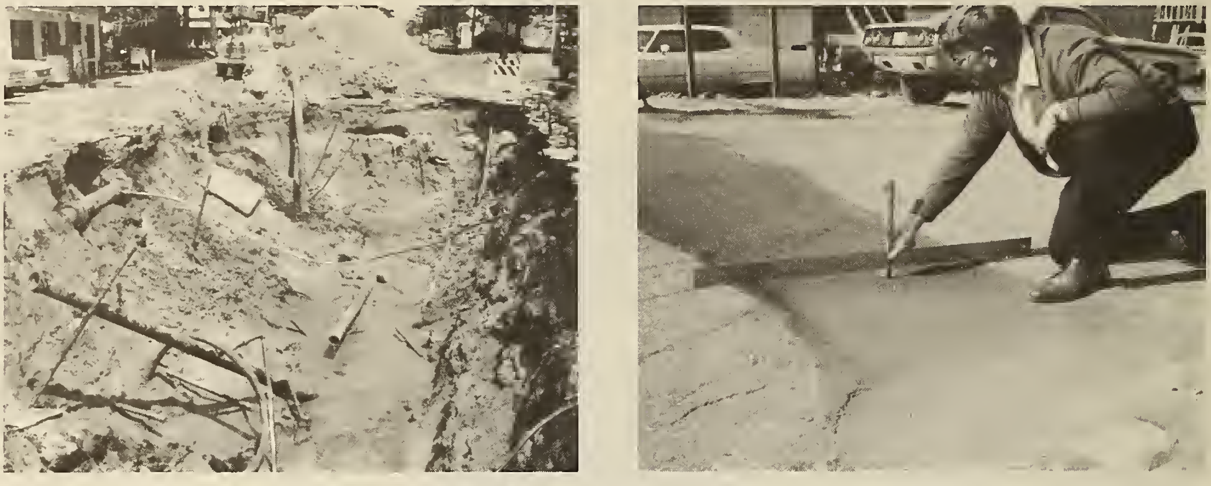
FIGURE 1 TEMPORARY PAVEMENT RESTORATION

surfacing material, using their color code and design at specified intervals along the trench length. This coding procedure has been ordained in New York City in accordance with the procedures outlined in the city's standard regulations. A method of control is needed and the color code concept appears to be a practical solution.

Multiple Use of Trenches and Poles

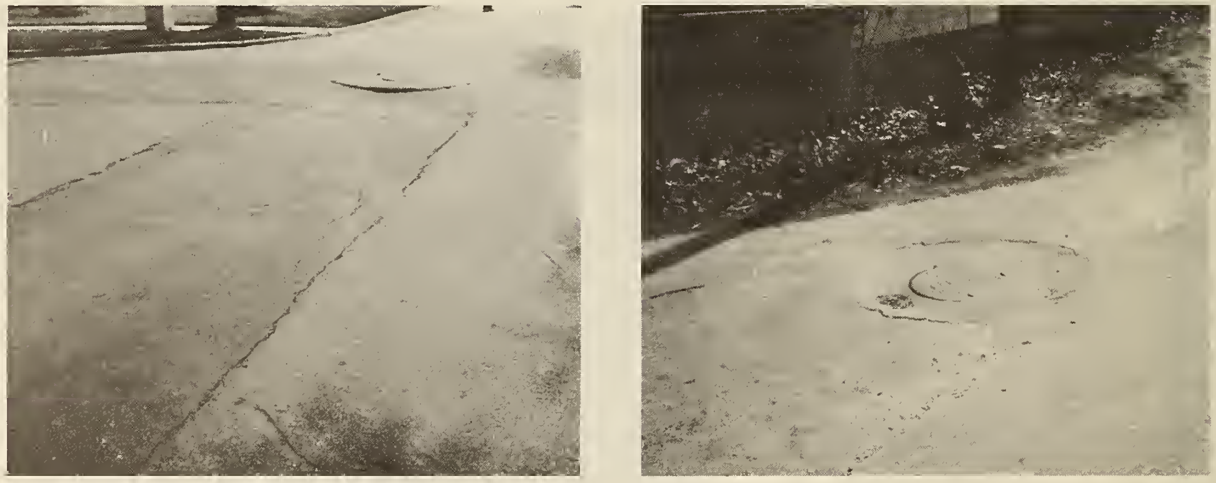
One partial solution for the multiplicity of underground utility structures is the use of a single trench for more than one utility. For those underground utilities which are amenable, and for which joint trenching could be utilized without safety hazards or complications in installation and servicing, this procedure offers economy for the companies and at least some alleviation of the underground tangle for municipal regulatory agencies.

Information obtained by the mail survey indicated that 22 percent of the agencies practiced joint trenching as common practice,



(a) Caved-in Trench

(b) Settled Permanent Trench



(c) Settled Permanent Trench

(d) Settled Permanent Trench

FIGURE 2 PERMANENT PAVEMENT RESTORATION

while an additional 37 percent allowed the practice. Only three percent of the agencies required joint trenching and 11 percent of the agencies prohibited it. In addition, it was noted that:

- Water and sewer lines are located in one trench in many urban areas. Most engineering and health authorities stipulate that water lines must be located at a higher elevation than sewer lines; water lines are often placed on a "bench" in the common trench; separation of the two services by no less than a certain distance is often stipulated by state and local regulations.
- Electric and telephone lines are often single-trenched because these utilities are often concerned about interferences in services due to currents, heat and problems of dig-up and servicing. Nevertheless, many successful examples of joint trenching was

found during the field investigations.

- Groupings of electric, telephone and gas are used, but less commonly. Fears are expressed that gas leaks, often more frequent than physical failures of electric and telephone services, could affect the utilities located in the same trench.
- New cable TV facilities are being trenched in many cases in combination with telephone; with electric and telephone; and often with electric, telephone and gas facilities.
- Street light conduits and traffic signal cables are jointly trenched, and they are sometimes joined with police and fire signal facilities.

The joint use of trenches is a subsurface manifestation of the more common procedure of utilities using joint poles for overhead long-distance cables, local lines and house connections. In fact, house connection electric and telephone use of common trenches is viewed with considerable favor, if the services are installed at the same time, as in the case of a new house or group of houses in a new subdivision development.

A sampling evaluation of joint overheading of utilities on common poles was carried out in connection with the mail survey. It showed that electric and telephone grouping was most common; electric, telephone and telegraph were commonly grouped; cable TV is now commonly poled with electric and telephone; and many groupings include every utility "in the books" – including city-owned utilities such as street lighting, traffic signal systems, police and fire alarm and communication networks.

The appended sampling analyses of both joint trench and joint pole installations support the above findings.

The field investigations bear out the joint trenching and joint pole-use findings outlined above. In Baltimore, joint trenching of water and sewers is not generally practiced but some instances of such common use are in effect where adequate separation of the two services give assurance of no hazard to water quality. Joint trenching is acceptable to the electric and telephone utilities, under conditions that guarantee safety and non-interference with the integrity of each facility. There is less agreement on the sharing of common trenches with gas utility plants. The city's ducting system is used by electric service but telephone utility lines are installed in that utilitiy's separate ducts. Multiple use of poles is common practice in the city and also in Baltimore County.

In Boston, water officials and sewer officials prefer separate trenching practices, however, standard city utility maps show that the two services can be, and at times are, installed in the same trench. This is particularly applicable in rock excavation, with the water main benched higher than the sewer line which is laid in the bottom of the trench. A 7-foot separation, centerline to centerline, is recommended as a minimum standard. Joint trenching is viewed with mixed reactions by the private utilities; joint trenching in tight quarters may be acceptable but telephone, particularly, desires to "go it alone." For house connections, the telephone and electric utilities have less hesitation about joint trenching. In the suburban community of Brookline, the private utilities express the same views as they do in Boston proper. In all of the metro areas surveyed, the same private utilities which serve the central city provide service in the suburban communities.

In Columbus, Ohio, privately-owned utilities accept joint trenching where this is possible without voltage interferences, heating and other adverse cable conditions. Only a minimal amount of joint trenching is in effect, primarily because Columbus is generally served by overhead facilities. Telephone and electric utilities recognize that joint trenching and ducting may become a "must" in the future but they stress their desire for separate manholes and vaults for control and servicing if and when layouts are ever universalized. Columbus water and sewer divisions evince no desire for joint trenching but no objections are raised to such locations for house service connections, with proper protection against contamination of the water supply.

Des Moines' privately-owned utilities accept the concept of joint trenching for street runs but such joint locations for house service lines are often inapplicable because these connections are not usually installed simultaneously. Atlanta utilities do not practice joint trenching. Under a joint venture between electric and telephone utilities, the desirability of joint trench use is being studied.

Utilities have regularly practiced joint use of poles. The mail survey indicated 99 percent of the respondents had such arrangements within their jurisdiction. Electric, telephone, both local and long line, telegraph, cable television, street lighting, traffic signal, as well as police and fire communications, commonly utilize joint facilities.

Figure 3, Joint Use of Poles, is a photograph of a joint pole in the City of La Mesa, Calif. A modern design without arms is used. At the top of the pole is 12KV, then 120-240 V, secondary; then CATV, telephone and street lighting circuits, fed directly from the secondary.

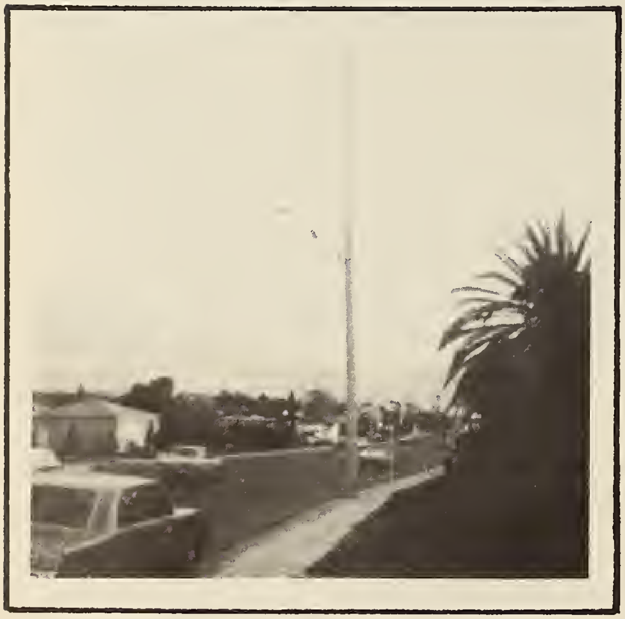


FIGURE 3 JOINT USE OF POLES

Telephone, electric and cable TV in Austin, Tex., practice joint use of poles on a regular basis. Telephone officials favor joint trenching but they point out the need for better coordination because they are doubtful about the "random lay" practices used by contractors. Surprisingly, the electric utility is still not entirely receptive to the joint trench concept. Gas does not join common trench ventures and neither does water and sewer because of maintenance and sanitation considerations.

In Phoenix, extensive use of joint poles is practiced by Mountain Bell Telephone, the Arizona Public Service electric utilities and Salt River project lines. Efforts are made to balance the ownership of the joint poles. The Salt River Project and the telephone utility maintain a joint-use contract for aerial services by which they exchange joint space on each other's poles and bill each other as necessary. The three private utilities have developed a Joint Trenching and Underground Facilities Coordination Agreement, dated January, 1972, to resolve conflicts encountered in subdivision underground work.

In Wichita, joint pole agreements between telephone, electric and cable TV are in effect. Joint trenching is less favorably viewed; joint locations are made inoperative in many cases because telephone goes underground in many locations where electric service remains overhead, even in new subdivision locations.

A negative attitude toward joint trenching is evidenced in Greensboro, N.C. The electric utility reported that it tried joint trenching with telephone lines some five years ago but the practice was discontinued when the latter utility had to install additional wire facilities to serve cable TV. Now that telephone is no longer serving the cable TV industry, telephone and electric are again exploring the feasibility and desirability of joint trench practices. The gas utility avoids any joint trenching overtures; it requires a two-foot separation from any other utility in order to assure the cathodic protection required for its steel gas mains.

Kalamazoo utilities use considerable joint trenching. Both telephone and electric utilities endorse the concept of "random lay" where the telephone cable is laid in the same trench and/or entwined with CATV cables and electric lines. Telephone views the "random lay" practice as beneficial because the power cable provides additional grounding effect for the phone cables. Gas mains may be installed in the same trench but this utility demands a one-foot separation from other utilities.

Ottawa demonstrates Canadian practice in relation to joint trenching. Ottawa Gas provided a trench for Bell Canada and the Ontario Hydro Electric Commission in subdivision developments; Bell and developers reimburse the gas utility as the developer is required by Hydro to provide a trench for underground installations. In central business districts, separate trenching is standard practice. Bell will not consent to joint use of manholes, especially with gas. In Winnipeg, telephone does not favor trenching because of problems of security and safety of personnel, time disparity and demand for different locations by utilities, in terms of both horizontal and vertical positions. Water and sewer utilities do not favor joint trenches.

The logistics of joint trenching work against its more general use, however. Minneapolis and Brookline Park have both found that the length of time that the trench may have to be left open to accommodate construction crews of more than one utility makes such joint use unfeasible. The General Telephone Company of Florida has also found that the exact timing of design, delivery of materials and cutover of facilities, as well as protection for maintenance activities, are key problem areas which must be overcome by partners in a joint venture.

Figure 4, Joint Trench, Baker, Louisiana, contains four photographs of stages of construction of a joint gas (PVC) and water main (C.I.) in the same trench.

Municipal Ducting Practice

No discussion of the problem of utility excavation and restoration operations would be complete without reference to utility ducting. Two documents of great importance to utility regulatory agencies in local governments, issued by the American Public Works Association in 1971, deserve serious consideration:

- "Feasibility of Utility Tunnels in Urban Areas" – A Comprehensive Examination of the Technical, Legal, and Economic Aspects of Placing Urban Utilities in Tunnel Structures (Special Report No. 39)
- "Proceedings on a Conference on Engineering Utility Tunnels in Urban Areas" – Sponsored by APWA and the Engineering Foundation, New England College, Henniker, New Hampshire (Special Report No. 41)

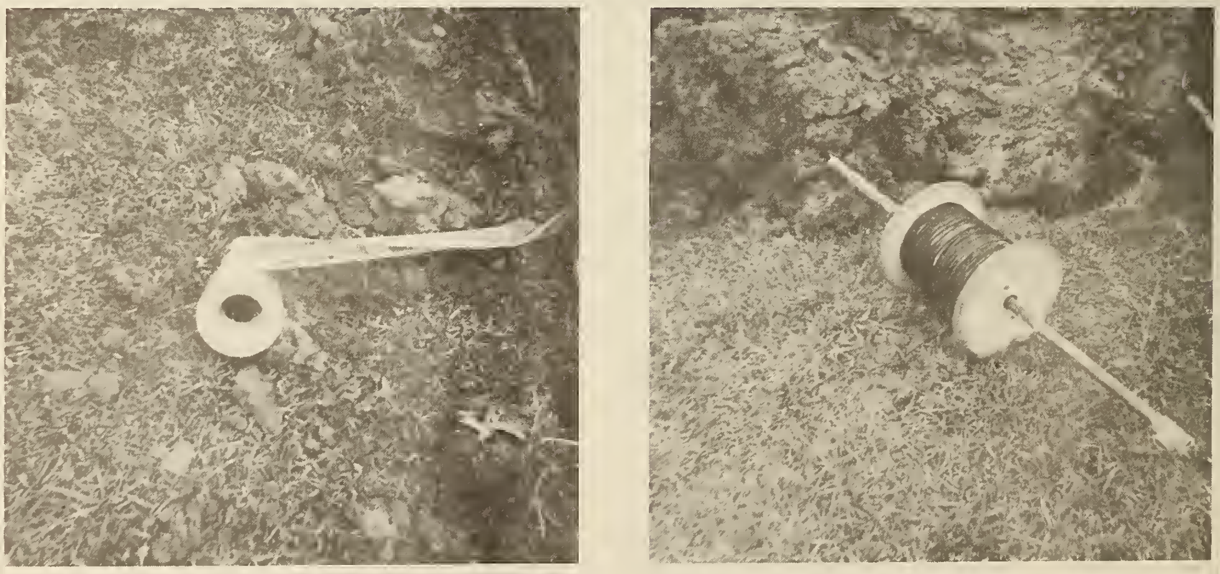
A variable alternative to the utility tunnel system is now in successful service in Baltimore and Montreal, and in some measure, in Verdun, Quebec. It will become the basic means of utility locations in a development in the City of Verdun to serve a unique residential community now being constructed on Nun's Island on the fringe of the city. This utility innovation is best described as a municipal ducting system, installed under local governmental aegis or by a duly constituted government agency with local or state or provincial authorization, for the location of those utilities who are required to, or choose to, utilize such structures for carrying their wire services. The system is operated as a business utility, with annual charges imposed for use of this system.

While the total coordination of major utility facilities in urban areas by means of utility tunnels may be unattainable now in most communities, the practicability, workability and economic feasibility of a "compromise" unification procedure have been demonstrated in representative cities in the United States and Canada. The municipal ducting system in Baltimore and Montreal are striking examples of how imagination and enterprise can provide a system of joint-utility handling and management that may be at least a partial solution for right-of-way underground crowding.

In 1909, the Provincial Legislature authorized Montreal to build, operate and maintain a system of underground ducts to serve as the location for all underground utilities which choose to use it instead of their own trenches, conduits or other means of transmission. The law required the creation of the Electrical Commission to administer the system. The duct system gained support by a regulation that no pole construction could be

a. Contract construction crew laying PVC gas main and CI water main in same trench View shows pipe being placed.

b. Contract construction crew laying PVC gas main and CI water main in same trench. View shows soil conditions.



c. Contract construction crew laying PVC gas main and CI water main in same trench. View shows tape being buried above gas line.

d. Contract construction crew laying PVC gas main and CI water main in same trench. View shows PVC gas line trace wire (although line is next to CI water pipe).

FIGURE 4 JOINT TRENCH, BAKER , LOUISIANA

carried out where these underground channels are available.

The institution of the Montreal ducting system was based on the success of the Baltimore duct program; the chief engineer of the latter system was retained to prepare a report on the advisability of installing the Montreal system, with a potential of serving approximately 30 firms which were franchised to install wires and poles in the city. The duct job started in 1913 and it now serves many users, including Hydro Quebec, Transportation Commission, Metro, Dominion Electric Protection Company, C.P. and C.N. Telecommunications, cable TV, street lighting, fire and police communications, traffic signals, cables for water pumping stations and sanitation system cables.

The city ducts extend 235 miles and are being extended continuously, as users request these facilities. The system is effectively managed and is reported to be a self-liquidating utility. It has helped ameliorate the city's underground space problem.

The success of the Baltimore and Montreal duct systems led the City of Verdun, at the outskirts of Montreal, to install its own "tunnel" utility, in the 1920's. Only 1.5 miles of duct were laid, with an average of 12 ducts per bank, as compared with the far more extensive Montreal system. The Verdun experiment never materialized; charges have been too low to liquidate and assure businesslike operation and revenues – 5 1/2 cents per foot per year, compared with the 11.6 cents Montreal rate. Telephone does not avail itself of the ducts of the two Quebec communities. Verdun is now making a going operation of a full ducting system to serve a new development community being constructed on Nun's Island. No overheading will be permitted in the Island development – a private investment project which involves many novel, innovative, creative features.

The pioneer Baltimore duct system represents a proven municipal answer to at least a portion of the underground utility accommodation problem by means of a coordination concept. Other American cities have developed government-owned duct networks but none predates the Baltimore program which dates back to 1898 when the Maryland system was authorized. It now has a total length of 5,000 miles, extended widely throughout the city from its initial location in the central business district. Extension is continuous, as utilities request the convenience of this means of undergrounding.

The ducts now serve the Baltimore Gas and Electric Company, the major user; telegraph; B & O Railroad; Penn Central Railroad; universities; industries; commercial buildings; and other non-public firms. By 1965, the system had 17 non-government customers, as well as 13 city and federal agencies. Formerly, city agencies paid no fees for duct space, but they now pay for service on a budgetary bookkeeping basis. The total footage revenue was over $808,000, of which the electrical utility paid over $587,000. The ducting system is controlled and administered by the Highway Division of the Public Works Department.

When the city legislative body authorized the construction of the ducting system in 1898, it also enacted a companion law requiring the undergrounding of overhead facilities. The full effect of this law has never been fully invoked and no predictions are made as to when total undergrounding will be achieved, but the city has provided and will continue to build an underground ducting system that will make the elimination of all overhead utilities possible. Telephone conduits have not joined the city duct system; this utility goes it alone with its own underground network, totalling some 300 miles of run. The city duct charge is seven cents per foot per year.

CHAPTER V
INSPECTION AND CONTROL PROCEDURES

An alert program of inspection and certification of right-of-way work provides assurance that the proposed utility construction, reconstruction, modification, relocation or repair have been performed in accordance with municipal requirements.

Without proper inspection of right-of-way work the regulating agency cannot certify whether its rules and regulations have been adhered to or abridged. The *honor system* can produce highly satisfactory right-of-way work but this does not change the fact that absence of official examination of the work negates the stipulations under which utility permits are granted. This simple fact is the most valid and most compelling argument for an orderly program of inspection of all utility work in urban rights-of-way.

Official inspection programs are not evidence of lack of confidence in the integrity of privately and publicly-owned utilities and of their intention to perform work in the public way with a high degree of compliance with all standards imposed by regulating agencies. It must be understood that the mechanics of right-of-way cuts, excavations and restorations are often assigned to third parties or even non-responsible employees of the permittee itself. Here, too, the precept holds that *everyone's responsibility is no one's responsibility.*

Extent of Inspection Programs

Inspection of earthwork requires detailed knowledge of soil mechanics and specific application of the principles of mass production quality control; i.e., strict procedural controls and tight material quality control.

Although the training of construction inspectors is beyond the scope of this report, it must be noted that inspectors must be adequately trained and that supervision must be supplied to determine that standards and practice of inspection are adhered to. The American Public Works Association has a construction inspector's training course which is regularly sponsored by chapters of the Association.

Regulation and control of work in the right-of-way has limited dimensions. The municipal government is not responsible for, nor does it have power over, the work performed on the "pipes and wires" belonging to privately-owned utilities. Privately-owned utilities – as well as city departments – have their own standards of workmanship and specifications covering materials and products for their physical facilities based on state and federal safety regulations. Each carries out its own inspection and control of work without intervention of the permitting regulating agency. The responsibility of the permit agency lies only in the rights-of-way which are in the public domain. Thus, the responsibility of government to inspect and certify proper workmanship is limited to the locations used within the right-of-way, to the way road openings are performed, conditions of the public way while such openings are in effect and traffic encumbrances exist, the way the excavation is backfilled and compacted, and how the pavement surface is restored.

Two general precepts express the role which construction inspection work plays in the effectiveness of right-of-way cuts and excavations, and restoration practices, and the ability of the regulating governmental entity to certify compliance with set standards and requirements: (1) efficient inspection programs act as the catalyst for workmanlike operations by both privately and publicly-owned utilities, and (2) no inspection program is any better than the knowledge, experience and dedication of the inspectional staff.

The mail survey provided limited opportunity for determining the effectiveness and thoroughness of the inspection programs of the 222 responding governmental agencies, in terms of the first precept. Rather, the data defined merely whether or not inspection work of some nature and of some degree is undertaken by the community. The responses offered no actual evaluation of the effectiveness of such field operations. On the other hand, the field investigations provided the means for a more incisive evaluation of inspection programs by both the responsible governmental officials and the visiting surveyor.

The summation of the mail survey findings disclosed that:

- 80 of the 222 communities provide what they consider to be full-time inspection of major work
- 144 communities operate what they consider to be routine progress field inspection programs of major work
- 122 make what is classified as final inspections on major projects
- Only 13 engage in full-time inspections of repairs and service cuts
- 139 communities provide routine progress inspections of repairs and service cuts
- 143 make final inspections of repairs and service cut work

The field investigations disclosed, generally, that most communities carry out some measure of inspection work in connection with utility right-of-way operations by units of a public works agency or an engineering division. The programs in the score of main cities and their satellite suburban communities vary from thorough coverage of all right-of-way projects, supported by laboratory tests of backfill compacting and other important construction practices, to merely cursory visual spot checks.

The greater degree of inspection for service cuts than for major utility work, as disclosed by the mail survey data, may be the result of relatively tight control of plumbing and drainlayer operations by building departments. Supporting this assumption is the fact that field investigations disclosed that building agencies do regulate service connections in many municipal entities. Not all inspection programs fall within the purview of public works; some municipalities vest such agencies as utility service departments, separate road units or even traffic and transportation departments with the responsibility of inspecting the nature of right-of-way restorations. Where duly designated underground utility coordinating committees or other agencies carry out right-of-way regulatory functions, inspection work may be carried out by a staff representing such a committee.

While inspection work, to more or less degree, is recognized as a necessary part of right-of-way regulation in the metropolitan areas visited, it is freely admitted by many officials that this phase of the utility control program is not always adequately performed. The main reason for deficiencies is a shortage of manpower, caused by lack of funds and failure on the part of the regulating agencies to recognize the importance of inspectional controls in fighting for budgetary appropriations. One means being considered to force adequate fund allocations for inspection programs is the use of contract bidding and arrangements with engineering-construction firms to perform this type of service, testing and other adjunctive operations.

Concern over inadequate and ineffective inspection programs is often allayed by the claim that defects in right-of-way excavation, backfill and surface restoration cannot be *hidden;* that they are eventually disclosed by pavement and trench failures. On this basis, some municipal regulating systems believe that the burden of work control and inspection falls upon the permittee, as long as it is required to guarantee the integrity of the right-of-way for a prescribed period. That, in essence, is assured by bonding utilities and such crafts as plumbers and drainlayers, as well as private contractors while performing work on their own – and not while working for bonded privately-owned utilities – to guarantee future maintenance or to pay the municipality for corrective actions. The validity of this thesis is not fully defensible. By the time evidence of improper backfill methods and material, compaction and surface restoration appears as trench depressions, damage has been done to adjoining surface areas, traffic has been affected, and the impedences of right-of-way re-digging and replacement operations must be expected.

Inspection Fees

The imposition of special charges for

inspection of utility work in the right-of-way is not common practice, much as such revenues might aid in financing employment of adequate inspectional staffs. Where an inspection fee is charged, it can be based on a flat cost at the time the permit is issued or the fee can be assessed on the basis of the amount of time spent by inspectors during review of job work. The hourly rates vary with the nature of projects and the policies of the regulating agencies. Hourly rates as high as approximately $10 were reported. In the case of some right-of-way work in subdivision developments, full-time city inspectors are required and their services are billed at cost, or at cost plus a large or small percentage.

Inspectors, in addition to check-up on construction work, are frequently used to verify trench cut dimensions, which serve as the basis for charges against permittees for city-performed permanent resurfacing work.

When the utilities are required to provide their own inspection operations, these companies expressed the opinion that their personnel are well trained and their demands on construction crews are as stringent as government control would be. In many cases, regulating agencies concur in this opinion.

Inspection Practices

The general consensus of the field investigators was that inspection practices are in need of improvement in many communities. The investigators' evaluations did, however, note the effective inspection programs in a number of central cities and suburban communities in metropolitan areas.

Baltimore's policies illustrate the principle of split responsibility for inspection control between city agencies, as well as the practice of requiring some utilities to perform their own job quality reviews. Utility work inspections are carried out by public works department personnel, while plumbing and drainlayers work is checked by the housing and community development department. When the city does not make inspections of privately-owned utility projects, the companies are required to provide their own control and to guarantee compliance with code requirements for backfill and resurfacing. Three field inspectors employed by the city are unable to cover the 200 right-of-way permits issued per week. A memorandum recently prepared by the public works department recommends the employment of four additional inspectors to provide full coverage of all work. When inspections are made by the city on privately-owned utility projects, it bills the companies at the rate of $3.50 per hour. If full-time inspection is required on major projects, the same hourly fee is charged.

Boston carries out a minimum amount of utility inspection work. The responsibility is placed on the permittee, backed up by bonding to assure compliance with city specifications. Public works officials agree that their inspectional efforts are inadequate and they are investigating the feasibility of contracting with an engineering firm to perform this work and to provide laboratory control of backfill compaction. Subdivision right-of-way projects are covered by full-time city inspectors, with developers paying the full cost.

Brookline, Mass., performs inspections of all work in the right-of-way; public works officials describe the program as "excellent to good." Manpower is made available for this phase of right-of-way regulation and control, contrary to the practice in the core city of Boston. No specific charge is made for inspections, except in the case of subdivision work; for development projects, the city stipulates that the "subdivider shall pay to the town an inspection fee of 1.5 percent of the cost of the required improvements as estimated by the commissioner of public works." The subdivision plat is not approved until this fee is paid.

Columbus, Ohio, places inspection responsibility on the permittee but the permit form states that "the city inspector will be paid at the regular rate of pay." The permit form also states that surfaces are to be replaced by the permittee "under city inspection." City-owned utilities carry out their own inspection work. The city engineer, the regulatory agent for the city, believes that inspection is adequate, even with minimal city involvement.

Upper Arlington, Ohio, follows the same procedure as its central city – Columbus. Privately-owned utilties are required to make their own excavation, backfill and surface restoration inspections; the utilities are required to make permanent surface replacement.

Des Moines carries out no consistent inspection program on minor cuts made by privately-owned utilities. Public works and traffic and transportation believe that no city inspection work is needed to assure proper backfill and temporary surfacing, and the permanent resurfacing performed by the telephone utility. Electric, gas and telephone provide their own inspectional programs. The city permit form states that the permittee will provide inspection by a professional engineer and efforts are being made to obtain compliance with this stipulation. The privately-owned utilities class their inspection programs as satisfactory; they point to the dependability of their trench restoration work. The city maintains full-time inspectional personnel on subdivision utility work.

Atlanta utilizes only one inspector to cover right-of-way work by utilities. The system is considered inadequate by city officials. On realty subdivision utility projects, city inspection is provided and the developer pays for such right-of-way work at the rate of three percent of the construction cost.

Privately-owned utilities in Austin, Tex., provide their own inspection of projects but this procedure is deemed unsatisfactory by the regulating agency because backfilling requirements are not consistently met. No charges are made for inspection work under the city's non-inspectional policy. When any city intervention is made in the inspection program, it is based on city and AASHO standards for compaction and testing of backfill materials and methods. The water and sewer divisions of the city use their own inspectors, who are certified by the state. City engineering personnel inspect water and sewer construction work in new subdivisions and on work performed by contractors who have been retained by the city for its major projects.

Backfill operations and surface restorations by Phoenix, Ariz., utilities are inspected by the construction engineering section of the department of engineering. All conditions imposed on the permit forms are enforced. A copy of the permit is transmitted to the inspection staff and pre-inspections must be made before construction work is started. The inspection fee is imposed when the permit is issued – $5.00 – and a charge is added for other costs and city services, at the rate of 20 cents per square yard of cut. The cost of inspection work is not covered by these minimal charges; the city is chronically short of inspectors because of insufficient funds for this type of service. The Salt River Project is authorized to make its own inspections.

In Tempe, Ariz., one utility inspector, working under the direction of the city engineer, covers locations of cuts, backfilling operations and resurfacing work. Utility work in subdivisions is inspected by other personnel, under the direction of the city engineer, with the cost met by the developers at rates established in the city ordinance covering such work. Mesa, Ariz., carries out inspections of all right-of-way work, under the direction of the director of public works. Fees charged for the permit phase of utility control and regulation cover both inspections and the checking of plans for projects.

San Diego inspection practices vary in some degree from those used in a number of other cities. Privately-owned utilities are required to inspect their own jobs when they are carried out with their own forces. However, if they retain private contractors to carry out trenching excavation and backfilling the city provides the inspection program. Routine inspection costs are imposed as part of the permit fees, when such permits are issued, or an extra work order is established for the collection of inspection charges. The city's inspection operations are carried out in four designated city areas, each supervised by a district construction engineer. Engineering inspectors check all construction in the right-of-way, including sewer and water jobs, street lighting, electric and gas projects under contract, as well as all city work. The telephone utility, by agreement, furnishes its own inspectors for projects. Subdivision project inspection, performed by the city, is charged to the developers, on the basis of a set fee schedule. Inspections on permit work are covered by the estimates made at the time the permits are issued. Inspectors' time, mileage, soil and aggregate tests, and core testing for street work are charged against individual work orders issued for major projects. Subdivision grading tests are carried out by a private testing laboratory and the costs are paid by the developer.

The City of Wichita employs one street maintenance inspector, working under the superintendent of public works maintenance. Utility companies advise him of the backfill jobs underway for each day and he checks the work for compliance with city requirements. In addition, the city engineer uses approximately 20 construction inspectors on city contract jobs. If the work load of the one street maintenance inspector is too great, some of these construction checkers can be pressed into service. The charges for inspection service are only *token* – from $1 per cut for the city engineer's inspections to $5 per cut for the street maintenance inspector's services. Officials have expressed objections to the lack of inspectional uniformity on utility work but they have not succeeded in obtaining adequate appropriations to increase their single-man capabilities. Water and sewer system projects are checked by their own departmental inspectors but projects under contract are inspected by the construction inspectors on the city engineer's staff.

In the City of El Dorado, Kans., the city engineer specifies backfill materials and methods, and inspectors and engineering personnel check on the progress of jobs and compliance with the conditions imposed in the permit.

Greensboro, N.C., inspectional policies are reported to be more rigid than those applied by the State Highway Department, primarily because the state lacks inspectional personnel. This is in contrast with experiences in other states where utility officials report that state right-of-way requirements are more rigid and more tightly enforced by inspectors. This *opposite* policy categorization may not be an accurate evaluation of local conditions, judging from one report that the state is more rigid in many respects than Greensboro and does not delegate as much authority to its field personnel, apparently reserving this authority to its office administrative staff.

Kalamazoo utilizes no formal utility inspection force, but depends on informal spot checks of utility construction sites by several city agencies. Inspection of trench restoration work is not carried out on an organized or systematic basis; although backfill compaction is specified as 95 percent density, using select granular materials, it is reported that trench restoration is judged by performance rather than by specification compliance. If the trench settles, the utility responsible for the project is required to make suitable restoration. The cost of such inspection as is carried out is absorbed by the city and no separate charge is made for this service.

Ottawa, Ont., represents the relatively small group of communities which has delegated utility inspectional work in the right-of-way to an underground utility coordinating committee. This body shares inspection of cuts and replacements with the city engineer's office. The cost of this service is recouped by the city via charges imposed during the permit-issuance phase of the regulatory program. The adequacy of the inspection program was rated as "fair" by the survey investigator. Winnipeg performs inspection work on right-of-way projects through district maintenance inspectors; adequacy of the program is classed as reasonably adequate.

Oakland, Calif., assigns inspection responsibilities to the construction division of the department of public works. The adequacy of the program is deemed satisfactory. The construction division imposes a charge of $9 per hour for inspection services. The East Bay Water Utility pays approximately $11,000 per year to the city for inspection services on its projects.

The Portland, Ore., inspection program is administered by the city engineer; the performance is deemed adequate. No direct charges are made for inspection work, other than the permit fee of $1 per cut. This *token* payment policy is typical of municipal practice.

Seattle's inspection program is handled by the city engineer. The permittee pays for inspections on the basis of $8.95 to $9.90 per hour.

Montreal places inspection responsibility in the road department. Permits are issued in the form of duplicate cards, the original of which serves as notice to the regulatory agency that right-of-way cuts will be undertaken; the permittee returns its permit card when the job is completed and a final inspection is then made. The inspection program is considered to be adequate. When inspections are not made during backfill operations, laboratory compaction tests are ordered if poor workmanship is suspected. The penetration test specifies that 25 strokes must not drive the test rod into the backfill material a distance greater than six inches. If the test is not approved, the utility is ordered to make correction; if corrective action is not taken, the city exposes the backfill, carries out its own restoration and bills on the basis of posted unit prices for trench work. The cost of routine inspections is covered by an established fee schedule for cut work. As is the case in many other cities, the inspection force verifies the dimensions of trench cuts, to serve as the basis for resurfacing charges. A so-called *cut fund* is maintained in deposit escrow by the finance department to cover inspection and surface restoration costs.

Verdun, Que., carries out its right-of-way inspection program with an inadequate staff. A plan prepared by the city engineer calls for augmentation of the present inspectional personnel to overcome acknowledged inadequacies. The city has the power to employ consultants for inspection and control of right-of-way utility cuts and restoration. The city may use penetration tests to confirm the compaction density of backfills. The city intends to utilize this regulatory procedure as part of the enhanced inspection program now being contemplated. Inspection costs are covered by the price schedule for cut restoration. To discourage extended periods of trench opening, the city imposes a fee of $5 per day for unfilled openings, ostensibly to cover repeated inspections of such sites.

In Baton Rouge, La., and Jacksonville, Fla., the cost of inspection programs, carried out by the engineering division of the public works department in each community, is absorbed in the general departmental budget.

Notification Practices

Reference has been made elsewhere in this report to the multiple involvement of various municipal agencies in the accommodation of utilities. The specific discussion related to two facets of the permitting program: dual or even triple involvement of various agencies in the issuance of permits and other phases of the regulating practice; and the clearance of applications with various municipal agencies which have their own utility plant in the underground space or are involved with the control of surface traffic and other conditions in urban areas.

Another aspect of the multi-concern of municipal agencies in right-of-way cuts and excavations revolves around the actual conditions existing in roads and streets when the permitted projects are underway and the inspection phase of these construction operations has been reached. Primarily, the involvement of other municipal departments and divisions, over and above the regulating agency's responsibilities to control right-of-way work, are related to surface conditions, traffic flow, interference with normal community life and living processes and protection of public health and safety.

In this connection, it is obvious that this concern involves such departments as police, fire, traffic, traffic signal control, building agencies, urban redevelopment and relocation authorities, planning and zoning bodies, and related municipal entities. The mail survey and the field investigation sought information on how lines of communication between regulatory agencies and other interested and involved agencies are maintained.

The mail survey developed information on the phases of right-of-way which are controlled and specified as requiring consideration. The items listed in the mail survey provide *clues* to the principle of cross-notification to various municipal agencies on the status of current right-of-way excavations and their impact on the urban environment.

Table 4, Extent of Control, lists the items which are controlled and regulated in the permitting-inspection program of 222 communities surveyed in the course of the mail questionnaire inquiry.

TABLE 4
EXTENT OF CONTROL
Local Agency Permit and Inspection Program

Item	Percent of Respondents
Extent of installation	61
Method of installations (open cuts, boring, jacking, encasement)	80
Horizontal and vertical location and clearances	73
Hours of operation	62
Protection of workmen (excavation, shoring, etc.)	37
Protection of pedestrian traffic	86
Protection of movement of vehicular traffic (barricades, signs, etc.)	92
Protection of trees, landscaping, etc.	72
Other environmental protection (noise control, etc.)	33
Protection of underground utilities	73
Storage of material, spoil, equipment, etc.	57
Backfill material	85
Compaction of backfill	90
Maintenance of temporary pavement	84
Pavement restoration standards	88
Landscaping	50
Cleanup	86

Source: Survey of 222 agencies, 1973 by APWA

When inspection work is carried out by city personnel, the items specified in the permit require examination and certification.

The field investigations disclosed the following cross-notification practices in some metropolitan central cities and suburban towns:

Baltimore's traffic engineering unit is part of transit and transportation and is, therefore, apprised of all right-of-way work; it enforces street traffic flow regulations and safety standards. Police are apprised of street openings; Fire is kept informed on street restrictions which might affect its movement to fire-fighting incidents.

Boston's supervising engineer, the permitting agent, keeps police and fire apprised of road closures through regular channels of communication. The traffic agency guides traffic and other surface flow conditions, as needed.

Columbus, Ohio, right-of-way cut permits pass through the hands of the city engineer, with obstructions of right-of-way referred to public service. Traffic is advised of all cut work that will affect vehicular flows, during the review of applications from utilities and the issuance of permits. The traffic unit of the police department is alerted to all cut operations.

Des Moines' permitting agency uses routine communications to make all agencies involved in right-of-way work or its impacts aware of pavement cuts that will affect surface conditions. Traffic and transportation is informed of each permit before it is issued. Police units are always advised of conditions that will affect traffic and result in any safety hazards.

Urbandale, Iowa, is typical of small-community, one-way permitting-inspection-control procedures. The city engineer encompasses most agency functions involved in adverse surface conditions resulting from right-of-way cuts. He notifies any other governmental units which he believes may be concerned.

In Atlanta, notifications of street or lane closures are given 72 hours prior to planned project cuts to the communications media, police, fire, traffic engineering, the Atlanta transit systems and Grady Hospital. These entities are expected to take appropriate departmental actions and to arrange for necessary detours of their equipment.

Wichita requires all privately-owned, as well as municipally-owned utilities, to advise the police department, fire department and the bus company in advance of making any excavations in the right-of-way.

Greensboro coordinates the barricading and closing of lanes and they are approved by the traffic engineer. He apprises police and fire of all pavement cuts that will affect traffic and the movement of fire-fighting equipment.

In Phoenix, notification of police and fire departments is also required, but in addition, the traffic engineer prepares a weekly press release which identifies the location of the various utility projects and the expected traffic problems.

Winnipeg's notification practice provides an insight into how an underground coordinating committee or other group can participate in all phases of intercommunication between involved units of government and private enterprise. The supervisor of the Underground Structures Committee serves as the central advisor on all right-of-way utility construction that could have impact on all right-of-way utility construction that could have impact on normal community activities.

Notification practices are a necessary part of any permit system.

Street Opening Accidents

As might be expected, any obstruction of the right-of-way can, under many circumstances, increase the hazard of accidents, both vehicular and pedestrian, in roads and streets. In spite of this potential correlation between street openings and street accidents, the relationship was not clearly defined as a result of the field studies. If anything, the general opinion of utilities was that such accidents are small in number and that it is difficult to charge obstructions and barricades with causing such incidents. The use of adequate safety devices, as required by city traffic regulations, and a high degree of prudence on the part of construction crews, are credited with reducing accident rates.

The utilities – both privately and publicly-owned – are hesitant to admit that their right-of-way operations contribute to traffic and pedestrian hazards; expression of such views could be detrimental to legal defense of claims made in courts of law. The data obtained in metro areas by investigators would indicate that only a minor number of accidents result from the tens of thousands of street openings recorded throughout the United States and Canada yearly.

Normally, police traffic investigation units are assigned the responsibility of investigating street accidents and recording the pertinent information on causes, conditions, and physical and structural effects of these incidents. All of the metro communities studied use police agencies for this purpose. In many cases, the raw information gathered by law enforcement agencies – supported by official accident report forms filed by parties to accidents and by supplementary reports prepared by police officers – is transmitted to traffic engineering officials who have the ability to analyze the facts and relate them to street and road conditions. The purpose of such data studies is to determine the conditions which impose correctable hazards, and to take steps to eliminate or alleviate them.

In view of the importance of dependable accident records and conclusions drawn from technical evaluation of such data, it is unfortunate that most municipalities do not collect and examine accident information relating to right-of-way utility operations. The mail survey disclosed the absence of such information in many of the respondent communities. Table 5, Accident Data Availability, indicates the availability of information on accident data:

The City of Oakland, Calif., reported that its records indicated that annually there were 0.2 accidents per mile for the sewer division, 0.005 accidents per mile for CATV, 0.024 accidents per mile for telephone, and East Bay Water 0.27 accidents per mile.

TABLE 5
ACCIDENTAL DATA AVAILABILITY

Item	Percent of respondents with data
Accidental dig-ups of buried utilities	23
Damage to utilities caused by nearby utilities	12
Trench cave-ins	18
Personal injuries related to underground work	28
Vehicular accidents related to street openings	38
Traffic volumes and travel-time delays	79
Extent of traffic disruptions by utility work	8
Storm damage to overhead lines	12
Effect of utility cuts on pavement life	6

Source: Survey of 222 agencies, 1973 by APWA

CHAPTER VI
LOCATION COORDINATION

As urban centers grow, populations increase, and industrial-commercial operations burgeon, utility services continue to expand in size and numbers of pipes and wires to meet the increased demands. More than that new utilities – such as cable television facilities – must, from time to time, be provided. Even if a no-growth policy should be adopted, augmentation and replacement activities would continue.

The mail survey clearly demonstrated how thoroughly population centers depend on, and receive, the services of from 12 to 20 types of utilities. The respondees indicated that: over 99 percent are served by water systems; 96 percent by sanitary sewers; 97 percent by storm or combined sewers; 98 percent by gas lines; over 99 percent by electric cables; over 99 percent by telephone service; 67 percent by telegraph lines; 51 percent by cable television; 97 percent by street lighting circuits; 92 percent by traffic signal networks; 53 percent by police signal alert lines; 69 percent by fire alarm systems; 18 percent by steam or hot water conduits; 6 percent by chilled water; and 5 percent by other miscellaneous utilities such as fuel oil lines.

The tabulation of data obtained in 222 communities is presented in Table 6, Ownership of Utilities, which indicates the utilities in service and the ownership thereof.

TABLE 6
OWNERSHIP OF UTILITIES
(Percent of Responses)

Utilities	In Your Community		Operated and Maintained by: (check all that apply)				
	Yes (1)	No (2)	Your Municipality (3)	Other Municipalities (4)	The County (5)	Special District Or Authority (6)	Private Company(ies) (7)
Underground:							
(a) Water	99		80	6	2	17	18
(b) Sanitary Sewers	96		91	3	6	21	2
(c) Storm Sewers	27		94	0	7	11	0
(d) Combined Sewers	41		88	1	6	11	4
(e) Gas	98		5	2	–	–	94
(f) Steam	18		8	3	3	11	86
(g) Chilled Water	6		–	–	9	18	82
(h) Electric Power	97		15	–	–	10	79
(i) Telephone	98		0	–	–	1	99
(j) Telegraph	67		–	–	–	3	99
(k) Cable TV	51		1	–	–	1	98
(l) Street Lighting	97		51	–	1	5	59
(m) Traffic Signal Cable	92		86	3	8	4	10
(n) Police Signal Cable	53		71	–	1	1	33
(o) Fire Signal Cable	69		77	1	1	1	25
(p) Other (Specify)	5		27	–	9	9	64
Overhead:							
(q) Electric Power	99		14	0	–	8	82
(r) Telephone	99		1	–	–	1	98
(s) Telegraph	67		1	–	–	1	99
(t) Cable TV	51		2	–	–	1	98
(u) Street Lighting Cable	92		42	1	1	5	60
(v) Police Signal Cable	45		65	–	1	3	36
(w) Fire Signal Cable	63		71	–	1	2	31
(x) Traffic Signal	72		81	2	9	1	16
(y) Other (Specify							

The multiplicity of utility ownership and competition leads to many conflicts for space. The challenge is most pressing where it can be solved only with greatest difficulty – in the closely built-up parts of older cities, the so-called CBD, the central business district. In new areas, such as in subdivisions or urban redevelopment sites, there can be no alibi if new accommodation practices are not improved over those inherent to the older areas of cities.

It is important to always keep in mind that both publicly- and privately-owned utilities and the road agency are operating forms of transportation and delivery to serve the public need. Thus, the use of the public right-of-way should be developed to benefit all users for all of their needs.

Cooperation and Coordination

Since competition for underground space is inevitable, and since this space will generally become more crowded in the upcoming years, the one condition that can alleviate the problem is a willingness on the part of all parties to accommodate their needs and desires to the requirements of others. The answer, then, to the right-of-way problem is *cooperation* and *coordination,* or as an alternative the stringent control by a governmental agency.

Reference to cooperation and coordination indicates that these two types of utility relationships are both exclusive and inclusive. They are both *alternatives* and *actions*, at one and the same time. Coordination represents government-to-utility relationships which have more or less formal character; cooperation is a spontaneous, unstipulated and voluntary action between competitors who find friendly and mutually helpful relationships mutually beneficial. Little if any utility service business competition exists in the United States and Canada; each privately-owned utility has a total non-competitive and exclusive franchise to render its kind of service – such as electric, gas and telephone. The non-competitive nature of water and sewer service is inherent. One interesting exception to this exclusivity is now experienced in cable television services where more than one firm serves some major urban areas. This freedom from business competition provides a favorable climate for cooperation in matters of right-of-way accommodation space.

It is almost universal practice for right-of way regulating agencies, based on the ministerial rights of government to manage its own public lands, to give publicly-owned utilities first priority in choice of underground space. Water and sewers enjoy this prior right in new street allocations; they have been given this first-choice right in all old right-of-way assignments and it is safe to state that this will continue to be the policy in all future utility operations. The rationale for this priority is obvious. When community services were first provided, just as they are today, the first essential of life was public water supplies, followed by sewers for the purpose of removing wastewaters from water-served properties. A prime consideration was also their flow characteristics, either gravity or pressure. The privately-owned utilities, until very recently, were located generally above ground.

Thus, privately-owned utilities – and certain municipal functions such as street lighting, traffic signal systems and police and fire alert networks – have been compelled to insert their underground facilities in the space left after the first-choice utilities have been installed in their preferential locations. In this situation, the ministerial rights of government to allot original space to its own facilities has had to be administered with a sense of cooperativeness, rather than with any flaunting of so-called *sovereign rights.* This has imposed the first criterion for cooperation between local government and its own utilities with the privately-owned utility sector; benign power has been practiced, rather than despotic power to make rulings and *make them stick.*

The problem of installing more and more utilities in less and less underground space would have led to more chaotic conditions than have been the case if it were not for an almost universal spirit of cooperative give-and-take between regulating authorities and utilities. The fact that so many communities are able to assess their right-of-way space conditions as non-critical, as some have disclosed in the survey studies undertaken in this project, attests to the ability of utilities to live together by cooperation.

Cooperation between government and private utilities evidences itself in such practices as giving these companies as much leniency as possible in allocating right-of-way space; giving privately-owned utilities choice of available space even if the choice does not always conform with standard locations, if no injury to a program of standardization would ensue; keeping utilities fully apprised of city street relocation, repaving and improvement programs which will affect the existing or future planning of their underground structures; development of municipal ducting systems which provide space for those utilities which choose to utilize them; inter-utility communications between city-owned utilities and privately-owned utilities in planning and consummating such projects as water and sewer system construction and reconstruction; and exchange of location data between these entities and of staking services to prevent underground plant interferences and dig-up damages.

These examples of cooperation are common experience in the United States and Canada. They depend on informal relations and lines of communication which are dictated by friendly helpfulness rather than by formal rules of conduct.

The other alternative to cooperation is coordination, by more clearly defined means. Spontaneous mutual helpfulness has proven effective in helping untangle the maze of utility placements in the underground. Any program of established relations that functions in consonance with rules of procedure between all interests involved in right-of-way matters offers even greater opportunities to make the best of bad situations and to evolve standards for future utility control which will be effective yet equitable, positive rather than punitive.

Coordinated efforts can be of various types: formally established programs which create underground utility coordinating committees with broad representation of local government regulating agencies, similar regulating officials from neighboring cities, publicly- and privately-owned utilities. Other communities have less formal coordinating groups that are activated on a voluntary basis. This latter type of coordination represents an intermediate step between the type of voluntary cooperation described above and the formalization of a duly constituted coordinating agency.

Probably the grandfather of utility coordinating committees is the Los Angeles Substructure Committee. It exemplifies the formally established advisory type of organization, having been formed in 1926 by action of the city board of public works upon recommendation of the city engineer. The committee operates under by-laws and a constitution adopted by its members, with elective officers. Membership includes representatives of all utilities, local governmental agencies and business organizations owning, operating, regulating or affected by facilities in the streets of the Los Angeles metropolitan area. The committee has met at least monthly on a regular basis since inception to discuss and coordinate the scheduling, potential conflicts and problems involved in utility accommodations on public works projects. Because of the increasing complexities of these discussions, the larger governmental units (such as the local district of the State Division of Highways, the city and the county) gradually formed highly specialized project coordinating units within their agencies (beginning about 1957). Since that time, the Los Angeles Substructure Committee has operated more on a policy discusssion and advisory level, serving as an open forum and sounding board for new concepts and review of existing practices in utility coordination, regulation and location.

Formalized coordination programs assume various forms. Such groups may be ordained by legislative action which stipulates membership composition, sets forth their powers and authorities, allocates funds for their operations and provides operational staffs. Others may be only semi-formal in format and only advisory in nature. Still others may be totally voluntary, with no powers other than the influence of close person-to-person communications and mutual decisions at meetings. There can be no substitute, however, for thorough staff work by the permitting authority and the utility. There must be:

1. Thorough planning and locating of the route of the proposed utility by the utility owner;
2. An analysis of the existing utilities in conflict;
3. A determination of what adjustments have to be made to avoid the conflicts;
4. A determination and agreement as to who will pay for such adjustments;
5. The issuance of permits after assurances have been given that such arrangements have been made; and
6. Coordination of the installation of the new facility with the adjustments of the existing facilities.

In the light of these fundamentals of utility cooperation and coordination, the mail survey and the field investigations were designed to determine what practices are commonly used and the results achieved.

A summation of the data received from the 222 mail respondents shows that 15 percent have officially constituted committees, having officers and functioning in accordance with rules and by-laws; 39 percent utilize coordinating groups which are held together on an informal basis; and 46 percent are without a form of coordination. The large percentage of communities that operate their utility accommodation programs without any coordination mechanism indicates a real need.

In the communities which have some form of coordinating agency, the average number of departments represented is 3.1. Other government bodies having membership on such agencies average 3.5. An average of 4.1 privately-owned utilities have membership on these coordinating committees. The average membership of these groups is 8.7. Fifty-seven percent of the coordinating agencies meet at regularly scheduled sessions and 43 percent meet only on an on-call basis.

The degree of authority of the coordinating committees was also determined. Only three percent of the coordinating agencies have formal authority to make binding decisions. Twenty percent of the bodies have the right to recommend decisions to some higher authority, but there is no indication that this advisory action need be followed by the duly authorized authority. The most significant finding of the mail survey was that 89 percent of the coordinating committees work out utility accommodation problems through mutual consent of the participants. The value of convening representatives of all concerned agencies and utilities and providing a forum for the voicing of opinions and experiences is demonstrated by the almost universal use of coordinating groups as discussion catalysts.

The mail inquiry revealed municipal practices which symbolized a spirit of coordination between government and utilities in formulating current municipal planning programs of development of a master plan for anticipated future utility needs. Eighty-three percent of respondent communities make projections of future utility needs; of these, 88 percent involve major utility lines, 90 percent involve the sizing of major lines; 44 percent cover projected right-of-way needs, and 64 percent project multi-year capital improvement programs.

These data have been cited from the survey summary because they assume great significance in the light of the respondent cities' efforts to coordinate their plans with the needs of both privately- and publicly-owned utilities. Thirty-two percent of the communities coordinate their planning programs with the utilities; 58 percent coordinate plans for street improvements and city utility improvement plans with those involving privately-owned utilities; 41 percent coordinate municipal planning for land use projects, or for projects involving land use policies, with governmental operation units, city utilities and private long-range plans.

The survey did not disclose how coordination is achieved – whether through coordinating committees, by means of informal conferences between the city and utility groups, or by means of individual contacts with each utility to ascertain the impact of proposed municipal programs on its utility plant. Regardless of this indeterminate nature of the coordination mechanism, the important fact is that neither the city nor the utilities go-it-blind into the future.

Field Practices

The on-site investigations explored the cooperation and coordination between all utilities and regulatory agencies.

- Chicago, Illinois, has had a coordinating committee for many years.
- Baltimore utilizes no coordination agency but the city keeps utilities apprised of its upcoming right-of-way programs. The privately-owned utilities maintain close contacts with each other on all projects which would have impact on others' space locations and physical plant.
- Baltimore County, served by the same privately-owned utilities which utilize Baltimore's rights-of-way, and provided by water and sewage interceptor-treatment facilities by the central city, follows the same coordination-cooperation procedures as its central community.
- Boston and its satellite suburban community, Brookline, function in the true pattern of metropolitan utility services. Both cities are served by water systems and sewage interceptor-treatment facilities provided by the Commonwealth-created Metropolitan District Commission, and by the same privately-owned utilities that not only cover the Greater Boston region, but in addition, other parts of the state. While Boston owns its own water and sewer lines, the consolidated nature of the utility services is symbolic of the regionalism concept of utility facilities. No utility coordination agency has been developed to serve either Boston or Brookline, in terms of privately-owned utility membership. A so-called coordinating group composed of Boston's public government agency representatives meets about once a month to compare their right-of-way plans. Brookline practices utility cooperation by following the principle of bringing utilities into conference to discuss every town project which could impinge on their existing physical plant and their future plans.
- A coordinating committee has been in existence in Des Moines for approximately seven years. It takes the form of a formally constituted agency but it is classified as *informal* because its status has not been formalized by legislative action. The city engineer serves as chairman of the group at monthly meetings. Upcoming city and privately-owned utility projects are discussed and means developed to coordinate development and construction of these programs. In the spirit of regionalism which a coordinating agency can foster, the city engineer of suburban Urbandale has been made a member of the voluntary group and he presents his plans for proposed projects to the same utilities which serve his community as well as Des Moines.
- Atlanta practices exemplify the cooperative principle. All relationships are totally voluntary, with the project managers of privately-owned utilities and department or division heads of publicly-owned agencies coordinating their efforts with others, on an as-needed basis. While not formalized or even partaking of the concept of a coordinated function, this cooperation motivation works effectively.
- A utility coordinating committee meets monthly in Austin, Texas, to discuss specific projects and to assure that utility relocations will have minimal effect on existing facilities.
- Phoenix, Arizona, has a coordinating committee which is organized on an informal basis under the chairmanship of the utility coordinator of the city's bureau of engineering. It meets monthly and invites representatives of nearby communities to attend whenever projects of regional import are to be discussed. An innovative feature of utility cooperation is in effect in Phoenix. The utility company representatives meet informally once a week, over and above attendance at the coordinating sessions, to

review their projects in new subdivision areas. Formation of a multi-community coordinating group is under consideration to serve the Tempe-Scottsdale-Mesa, Arizona, area 10 to 15 miles east of Phoenix. At present, each community deals with its utilities on an individual basis.

- The San Diego utility coordinating committee meets twice monthly to bring together representatives of all franchised utilities and of city departments which operate utilities or regulate utility operations. The committee is unique in that it was formed by the local APWA chapter. Membership is required for all utilities with installations in the public right-of-way, in accordance with the Manual of Administrative Practices for Utility Installations. The spirit of mutual trust and interest is reported to be excellent.

- A utilities coordinating group, the Kalamazoo Area Utilities Protection Committee, was started in 1966. It meets monthly to discuss utility-right-of-way practices and planning. The voluntary cooperation between the utilities has been enhanced by the person-to-person relationship engendered in the Protection Committee. One major outcome of the coordination program has been the creation of *CONA* – Contractors One Number Alert – three years ago, to reduce accidental dig-up damages in the right-of-way.

- An excellent program is in effect in Ottawa, Ontario, where a utility coordinating committee was started 25 years ago to regulate the placement of utilities in city streets, to keep records of construction work, and to develop underground maps. The utilities which maintain membership in the committee, and their share of the cost of administering its work are shown in the following tabulation:

Members	Cost Share – %
Ottawa Gas Company	19.0
Bell (Telephone), Canada	9.5
Ottawa Hydro-Electric Commission	9.5
Public Fuels Transmission System	1.0
Ottawa Cablevision	1.0
Ottawa Carleton Region	
Works Department	21.0
Roads Department	8.0
Traffic Department	1.0
City of Ottawa Engineering Department	
Sewer Section	18.0
Roads Section	9.0
CN/CP Telecommunications	1.0
Skyline Cablevision	1.0
Ontario Hydro-Electric Power Commission	1.0

Administration of the UCC program is directed by the sewer branch of the City of Ottawa, with policy established by the committee. The committee has an elected chairman and a secretary who is a professional engineer. Ten persons work for the committee – technical assistants, instrument men, survey crewmen, and draftsmen – augmented with additional college students during summer seasons. Two vehicles are used – a car and a panel truck. Each year the UCC registry prepares for all members plans showing the capital projects proposed by each utility member. to serve as the starting point for the coordination and control of work programs. The resurvey and mapping of streets which have, in the past, been subjected to major reconstruction is continued yearly.

The mapping and preparation of plans completed to date represents 77.7 percent of the present city's built-up area. New and abandoned installations are continuously mapped, as well as details of new curbs, sidewalks, curb returns, traffic lanes and poles added or removed. UCC has set standards in residential areas utilizing boulevard spaces, and utilities in the downtown older streets are located wherever practicable. The City of Ottawa issues utility permits, rather than the committee. The UCC has no executive officer.

- In Winnipeg, Manitoba, the coordinating group principle is carried out to an even greater degree than in Ottawa. The Metropolitan Corporation of Greater Winnipeg, the Gas Company, the Manitoba Telephone System, the Canadian Pacific Telecommunications and the Canadian National Telecommunication Systems, and the Manitoba Hydro-Electric Board have each entered voluntarily into an agreement to support a committee known as the Underground Structures Committee for the purpose of coordinating the use of city streets and the Metropolitan Corporation (which were amalgamated January 1, 1972, with twelve smaller cities and suburban municipalities into one *Unicity*). The committee is chaired by the city engineer, who has no voting power. Eight members constitute the committee, four appointed by the city to represent its Hydro-Electric System, the Water Works and the Sewer Maintenance Branches, the Design Branch and the Streets Branch of the Engineering Department; two members from the former Metropolitan Corporation of Greater Winnipeg; and one each by the Manitoba Telephone System and the Greater Winnipeg Gas Company. In addition, there are five non-voting members representing the CN/CP telecommunications companies, other utilities, and the city.

The committee's duties include: making a study of present utility structures and recording them; formulating plans and adopting standards for future utility underground structures; making recommendations in regard to location of underground structures and joint-use tunnels; keeping official records of all underground facilities; investigating and reporting on all requests for street and lane closings and openings and recording time and other functions.

A staff is engaged by the city, on recommendation of the committee, to perform all duties, and office space and equipment are provided. All applications to the city engineer for utility permits are referred to the committee staff for consideration and the staff advises the city of its recommendations. The committee program had its inception 20 years ago; it has established standards for utilities in the Inner City. A suburban underground structures committee, in 1967, established standards for the location of water, sanitary sewers, storm sewers, metro water, metro sewers, gas, telephone, hydro power, city signals and street lighting. It is agreed that the Underground Structures Committee has rendered invaluable service and that it would be inadvisable to go back to the unilateral control system previously assigned to city departments.

- In Denver, Colorado, an informal utility coordinating group was developed in 1959 during the planning of a major urban renewal project. Representatives of this group envision that it will become a formal body under the direction of the public works manager. If this occurs, the formal agency will be supported indirectly, with representatives from each agency *on loan* to the group and with direct capital support limited to management, clerical personnel, and overhead items. Mountain Bell is in the process of initiating a coordinating mechanism for right-of-way acquisition; and the Public Service Company, in conjunction with Mountain Bell, is developing a records system which initially will be limited to mapping utility locations.

- A Utility Underground Coordination Council has functioned in Oakland, California, for the past ten years. In Fremont, Newark and Union City, California, the Washington Township Public Works Coordinating Committee was created in 1957. Portland, Oregon, underground utilities are coordinated by the Metropolitan Utility Coordinating Council formed in 1955. A utility coordinating council meets quarterly and on-call in Seattle, Washington; it was created five years ago.

These examples are quoted to show the diversity of municipal practices, ranging from simple cooperation with utilities, to the establishment of formal utility coordination councils vested with many of the regulatory functions normally assigned to some branch of city government. The Manual of Improved Practice, which has been evolved from the studies outlined in the Report, makes the firm recommendation that *underground protection unification agencies should be authorized by all urban regions where this action is feasible, legal and economically achievable.*

Contractor Assistance

The underground has become so interlaced with buried utilities in many urban communities that it is often hazardous to excavate or repair facilities of any sort without previous assurances that the way is clear, or the exact location of other utilities known. These hazards include not only actual striking of structures, but secondary effects on them by weakening their foundations and surrounding supporting soil. The complexity of the underground makes it impossible to *dig in the blind.*

To prevent such digging dangers, utilities offer information to other utilities, contractors, plumbers and drainlayers, and individual property owners on the vertical and horizontal locations of their facilities, and their nature and dimensions. This applies to privately-owned utility companies and publicly-owned utilities. While control of underground work is maintained by regulating agencies, via the receipt of applications and issuance of permits for excavations in the right-of-way, authorization to dig is no guarantee that interferences and damages will not occur. Supplemental information from the utilities, backed up with staking assistance, is necessary to prevent serious effects.

One solution to the dig-and-damage problem would be a totally dependable, all-inclusive record of underground utilities, in the form of a master map, and master cross-reference records. Such records could be consulted whenever an application is received to open right-of-way space for specific purposes and the impact of such proposed work could be determined by checking horizontal, vertical and structural dimensions in the area of the contemplated cut. Studies have shown that such master pinpointing is not generally feasible; that only a minority of communities maintain such records. Where records are available, their total accuracy and dependability are suspect.

The subject of utility records and master planning is reviewed later in this chapter. Where utility coordination groups are in existence, one function of such a unified agency could be the mapping and recording of all underground utilities; more than that, these records could be kept up-to-date by the coordinating agency's activities in approving of permits, or being the recipient of records transmitted to it by the municipal regulating agencies.

In the absence of such master utility records in the possession of government agencies or coordinating groups, the problem of protecting the underground against digging damage must be handled by consulting a multiplicity of utilities and getting clearance from each. Any by-passing of this procedure – and the temptation on the part of *diggers* will be to avert the time-consuming task of multiple check-ups – poses a threat to the integrity of underground utilities.

To overcome the problem of multiple contacts, many utilities have set up, or are setting up, various forms of *call-before-you-dig* systems and publicizing the importance of obtaining *before-the-fact* information on what will be encountered wherever excavations are undertaken. These call programs vary from *each utility on its own* systems, to unified *one-number call* arrangements. In the latter case, a single clearing house for underground inquiries is maintained and publicized and the master or central unit then informs all involved utilities of proposed right-of-way work. Each may then stake or give information directly to the excavators. The mechanics of how such a system functions, who mans it, who pays for it, and its effectiveness as a clearing house device vary, but the concept is an example of coordination, whether it is operated by a coordinating group or by voluntary participation on the part of individual utilities which pool their concern with, and interest in, the safety of all underground facilities.

Call programs usually require staking-location services to translate utility records into on-the-ground marking of the locations. This will avoid damage whenever the records show the presence of other existing structures at proposed cut locations.

Almost all water, sewer, gas, electric and telephone utilities provide field location services to spot buried facilities for callers. The accuracy of surface location services is not guaranteed because a sizeable portion of staking-location services are based on records which may not be current or in the *as built* category. Instruments or *finders* are used to verify records in 50 to 60 percent of the cases; uncovering by test digging or test pit work is far less common – in only about 10 to 15 percent of the location services.

The *call-before-you-dig* program will not work unless penalties are imposed for *blind* digging, or intensive educational programs are provided to inform the public and contractors of the hazard of such operations. Utilities – individually and as unified groups – use various means for carrying out such education and warning programs: advertising in telephone directories or newspapers; publication of special directories; placing of warning stickers on all rentable equipment; give-away pencils, rulers, paper pads; issuance of flags, posters and other attraction-getting materials.

The mail survey disclosed the predominance of *call* programs. Eighty-seven percent reported such alert systems. Only 35 percent reported the use of a central clearing house and two-thirds indicated that the call systems used in their communities were of the nature of *each-utility-for-itself*. In a number of cases, the telephone utility has, naturally, taken the lead in providing a single-number arrangement.

The mail inquiry was specific about the availability of staking-location services by utilities. Table 7, Field Location Services, presents a summary of these survey findings.

TABLE 7
FIELD LOCATION SERVICES

Utility	Field Location Provided (%)	Method of Location (%)		
	Yes	Records	Instruments	Uncover
Water	98%	71%	62%	14%
Sewers	96	91	17	14
Gas	97	64	67	15
Telephone	97	67	56	13
Power	95	77	46	13
Other	13	79	58	29

The respondent communities in the mail survey indicated that 23 percent have experienced accidental dig-ups of buried utilities; 12 percent reported damage to utilities caused by faults in nearby utilities; 18 percent reported trench cave-in problems; and 10 percent have experienced problems of gas accumulations in manholes and vaults. These conditions are indicative of the need for coordinated programs relating to underground utility protection. Present OSHA requirements require notification of utilities before digging – without defining responsibility for determining which utilities are present and thus need to be notified.

The general findings of the mail survey were confirmed, in more or less degree, by the on-site investigations.

- In Baltimore, no concerted call-dig program is in effect. However, each utility carries out its own alert program. Telephone numbers are publicized, particularly on behalf of the Chesapeake and Potomac system, by means of placards, stickers and warning signs. City permit forms are imprinted with rubber stamp warnings to permittees to call gas and electric utilities before *you dig, drill, blast, etc.*
- A one-number alert system for control of dig operations is being considered for experimental try-out in Suffolk County (Boston) first, and then expanded to the wide area of the state which is served by the same utilities, including the region served with water and sewer services by the Metropolitan District Commission. Independent call-dig contacts are in effect for the individual utilities and city-metro utilities. A state statute requires all persons who excavate to apprise utilities not later than 48 hours before jobs are started. This law could be used to promulgate a universal *call-before-you-dig* program; this can be a valuable statutory provision.
- While Des Moines utilities do not participate in a unified *call-before-you-dig* program, an effective version of it is in effect. Stickers list the numbers of all privately-owned utilities and city service

agencies and a phone listing for call-up is contained in the city directory. Staking cooperation between the utilities and the city is excellent. The Utility Coordinating Committee serves as the motivator of the coordination program now in effect.

- Atlanta has no formal call-dig program covering all utilities. The telephone company is the most active utility in the call alert plan but no literature is distributed. The gas company has a *call-before-you-dig* policy, as required by Georgia law (House Bill 128).

- Houston, Texas, utilities have initiated a one-number-call system, with a central listing which operates on a 24-hour basis. The cost of this service is shared by all local utilities. An extensive publicity program including films, sketches, posters and handouts has been maintained.

- Phoenix, Arizona, utilities maintain individual call-dig numbers and location-staking services but no central one-call arrangement is in effect. The telephone company marks locations on the ground within a 24-hour notice at no cost to the contractor. It places decal warnings of the hazard of promiscuous digging on all construction equipment and issues wallet cards to construction personnel.

- In San Diego, individual utility *call-before-you-dig* programs are in effect. The gas and electric utility maintains its alert program on a system-wide basis, via a central contact location. A marking service is provided for contractors, with the stipulation that the digger must assume responsibility for verifying the location indicated on the surface markings.

- The telephone utility in Wichita, Kas., offers marking service and takes responsibility for underground damage if the contractor adheres strictly to its location instructions.

- The utilities – private and public – in Kalamazoo sponsor a unified call program, funded by the participants. The system has been effective in reducing accidental dig-ups; it is estimated that 85 percent of all excavations are made only after the call-up alert system has been utilized. The monthly cost of the unified operation is approximately $800 per month which includes the phone answering service and at least five teletype machines.

- The Ottawa program is worthy of note. The inviolable rule is that *no one can put a spade into any street in Ottawa without a permit from the city engineering department-sewer section.* As a precedent to the issuance of any permit for right-of-way work, the applicant must assure the permit officer that he has notified all of the utilities concerned that his digging project will be undertaken.

- Oakland, California, requires all permittees to call before they dig in the right-of-way and this regulation is made a part of the permit form.

- In Los Angeles, California, the substructure committee has published a *Substructure Damage Prevention Directory,* now in its 6th edition, which lists telephone numbers for all governmental, utility and transit agencies in over 100 communities in the metropolitan area. Over 12,000 copies of the current edition have been distributed.

- In the case of Baton Rouge, Louisiana, the existence of the Utility Coordinating Council has not resulted in a unified, coordinated *call-before-you-dig* program. It has, however, stimulated individual call programs by each utility. Stake-out of right-of-way excavations is encouraged. Each utility is assigned a different stake color which helps distinguish that utility's work and its underground facility location markers in all multi-utility projects.

The community highlights offer an insight into the variations in local practices. They show the general use of *each-utility-for-itself* call programs; the effectiveness of unified one-number call systems; the method of operating central systems and distributing information via teletype equipment; the methods used to alert diggers of the hazards of *blind* excavation work; the need for unified programs that will be regional rather than localized in scope; and the role which underground utility coordinating committees can play in catalyzing *call-dig* programs and making them functional.

CHAPTER VII
RECORD SYSTEMS

Programs for utility location and coordination can not be effective without the development and maintenance of records concerning the location of all utility facilities and plant within the right-of-way. Records are needed for the planning of new, replacement or relocated facilities, as well as for emergency repairs.

The most important record that a community should maintain is a detailed real estate map. A common scale for such a map is 1 in. = 50 ft. These maps usually show lot sizes, street right-of-way dimensions, lot and block numbers, street names, and subdivision names. As the information becomes available survey monuments, house addresses, and names of property owners may be added to the record. The latter are taken from the assessment rolls and require constant revision, usually yearly. Such maps are usually maintained by the assessor for the city or county. Where property ownership changes rapidly, such maps generally cannot be relied upon for ownership and research must be performed for individual areas as needed.

With the basic information, a coordinated series of maps of underground services may be prepared. The underground plans (maps) should include records of all existing underground utilities as well as recommendations (notes) for all future work involving extension of underground utilities, relocations, enlargements of existing utilities and additions to the same and all similar underground improvements. Maps may contain information for all utilities or each utility may be mapped separately, but all at the same scale.

The planning work, thus, must begin with well-prepared and complete maps of all underground utilities.

General Requirements

The underground plans should include standards for the preparation of all maps including:

1. Detail sheets, street intersection plats, and master control plans;
2. Record sheets for depicting new background construction before backfilling commences;
3. Street cross-sections showing recommended locations for underground utilities in various sections and for different street widths;
4. Manholes, vaults, and tunnels for all utilities, with particular reference to requirements for length and width;
5. Methods of tapping (connections) all utilities with particular reference to possible interference with existing and future underground utilities;
6. Regulations for repairs to pavement after *utility cuts,* and
7. Permit forms required for all underground construction.

The plans thus developed should be kept up-to-date to accommodate changes in the master street plan, building developments, industrial developments, population changes, neighborhoods, etc.

Standards for recording data, i.e., plan scale, areas to be covered, strip sheets, and master plan, should be established before work commences. Scales of 1 in. = 20 ft are in common use to depict new underground construction, particularly in congested areas. This scale facilitates recording changes in location of utilities, connections and new construction.

It is, of course, essential that recorded reference points be established in the areas to be mapped, as well as accurate bench marks for running levels. Details as to the scale of maps and their type need not necessarily be set down with any degree of rigidity. It is sufficient to state that the scale should be adequate and the records should have a high degree of permanence. A perfect system should not be the aim; rather, a simple, practical system capable of being digitized and computerized should be provided.

As discussed in Chapter III, most communities require a permit for cutting and excavating within the public right-of-way. However, such permits are not generally demanded from publicly-owned utilities. The permit form offers an excellent opportunity for the permit agency to capture information concerning the work which is done. However, as a source document it lacks the value of an as-built plan inasmuch as field changes are often made.

Records of the City of Winnipeg are kept on a non-computer basis and the congested area is mapped on a scale of 1 in. = 20 ft, while the residential areas are mapped 1 in. = 40 ft. Standard placement of utilities has been effected and inner city and suburban placement plans are also included.

The City of Vancouver, B.C., has established a computerized management system to measure street and lane conditions for leak history and maintenance costs for the water distribution system, for the city's communications network and for traffic sign installations. In each case computer programs are used to generate a variety of information reports from these systems as the need arises. The system is based on a coordinate layout. The cities of Ottawa (National Capital Commission); Phoenix, Arizona; Portland, Oregon; New York City; Arlington, Virginia; Metropolitan Toronto; and Los Angeles and some utility networks have either devised or are planning computerized systems.

Types of Records

The mail questionnaire asked for information on all manner of utility accommodation in public rights-of-way. Insofar as records are concerned, the following was reported:

1. Only 21 percent of the respondents employed a central repository for records.
2. 99 percent of the respondents reported that each utility kept records of the structures owned by them in the public right-of-way.
3. Table 8, Status of Municipal Utility Records, lists the replies by each utility service.

   For water and sewer services, good municipal recording is in effect but only between 53 percent and 59 percent of the respondents report that they are complete and up-to-date, and between 87 percent and 95 percent that the records reflect as-built conditions.

   For the other principal utilities, i.e., electric, telephone and gas, between 45 percent and 51 percent of the respondents reported that municipal records concerning the same were complete and up-to-date. However, many agencies have found that better cooperation is obtained from private utilities by soliciting specific information for individual projects. This may involve a two-cycle review in which a basic layout is first reviewed, and then reevaluated after modifications have been made.

   Again insofar as *as-built* conditions are concerned, only water and sewer have good records; the others average about 50 percent.
4. Governmental agencies usually keep their utility records in the form of engineering drawings or an official utilities map (99%

TABLE 8
STATUS OF MUNICIPAL RECORDS ON UTILITY LOCATION

	Records Maintained	Status				Records Reflecting As-Built Conditions	
	Yes (%)	Complete & up to date (%)	Fairly Complete & up to date(%)	Some Records	None	Yes	No
(a) Water	95	53	39	5	3	87	13
(b) Sewer	99	59	39	2		95	4
(c) Electric	50	29	30	20	23	56	44
(d) Telephone	45	17	27	26	29	49	50
(e) Gas	51	21	35	23	20	52	47
(f) Others	18	34	23	27	25	67	32

of those reporting). Some, in addition, (23%), also microfilm; one percent use computerized data files; and three percent utilize various other methods. Computerization will be dealt with at some length at the end of this chapter.

5. Geo-coding systems are starting to emerge; five percent of the respondents reported that they are installed and operating, three percent are studying this procedure, and 88 percent are not yet employing the system.
6. One hundred sixty-eight municipalities provided their *best estimate of the average number of cuts (annually) of all utilities combined.* The average number of cuts per year for all respondents was 1,985. Table 9, Number of Utility Cuts, displays the data by municipality population categories. As would be expected, average cuts per year vary directly with the size of population (population being an indicator of utility network size), from 226 cuts/year for cities in the 10,000-50,000 group to 15,482 cuts/year for cities in the over 500,000 group. The same table also provides data by metropolitan status. Urban places averaged 201 cuts/year, suburbs averaged 396 cuts/year, and central cities averaged 3,713 cuts/year.
7. Cost data are kept by many municipalities relating to construction, operation, maintenance, and servicing or repair. Again, the most incomplete information applies to combined sewer, electric, telephone and gas and other miscellaneous utilities. Table 10, Availability of Cost Records, presents the relevant statistics:
8. Additional records include data on:

ITEM	Percent of those Reporting
(a) Accidental dig-ups of buried utilities	23
(b) Damage to utilities caused by faults in nearby utilities	12
(c) Trench cave-ins	18
(d) Personal injuries related to underground work	28
(e) Problems of gas in manholes and vaults	10
(f) Vehicular accidents related to street openings or utility work carried out in right-of-way	38
(g) Storm damage to overhead utilities	12
(h) Traffic volumes and travel times on various municipal streets	79

TABLE 9
NUMBER OF UTILITY CUTS

(a) by Population Category

Population (000's omitted)	Number of Respondents	Mean Cuts/Year	Range of Responses
10 - 50	64	226	20 - 1,500
50 - 100	43	580	25 - 5,000
100 - 250	38	2,574	50 - 36,510
250 - 500	13	3,192	500 - 7,000
over 500	10	15,482	1,000 - 70,000
Total	168	1,985	20 - 70,000

(b) by Metropolitan Status

Metro Status	Number of Respondents	Mean Cuts/Year	Range of Responses
Center City	82	3,713	25 - 70,000
Suburb	60	396	21 - 5,000
Urban Place	26	201	20 - 600
Total	168	1,985	20 - 70,000

TABLE 10
AVAILABILITY OF COST RECORDS
Percent of Respondents Maintaining Records for

	Installation Costs/Foot	Repair Costs	Routine Servicing Costs	No Data
(a) Water	70	46	31	27
(b) Sanitary Sewer	76	45	36	20
(c) Storm Sewer	72	39	28	23
(d) Combined Sewer	33	24	16	61
(e) Electric	16	12	8	82
(f) Telephone	4	6	3	94
(g) Gas	9	8	6	88
(h) Other Utilities	6	5	4	91
(i) Pavement Restoration	54	50	17	28

(i) Extent of traffic disruption due to utility work in street rights-of-way	8
(j) Effect of utility cuts on pavement life	6
(k) Environmental effects of utility accommodation practices	2

The only record in the above list having a semblance of completelness is that maintained in most cases by the police department relating to vehicular accidents.

The additional data shown is of great importance in evaluating utility and municipal performance. All of the listed records should be kept.

In many cases, the cost factor is the principal reason for the lack of systematic, complete records. However, in some cases, there may be a legal responsibility for record keeping for the purpose of the finding of and damage to underground utilities; the rules of the California Public Utilities Commission are given in the Exhibit, Record Requirements–- California Public Utilities Commission. (Many other regulatory bodies have similar rules.)

Such complete duplicaton of records may not always be warranted. Rather, establishment of effective referral and information furnishing systems should have a high priority. If on an annual basis copies of base maps were provided to the local agency, design and maintenance operations could be performed but complete reliance would not be placed upon information which may very well be outdated.

Exhibit
Record Requirements – California Public Utilities Commission

Each party operating or owning facilities shall, upon request, provide information as to location of its underground facilities to any other party contemplating underground construction, or work in the vicinity thereof. Provision of such information by a party will not relieve such other party of his responsibility to locate accurately such underground facilities and to exercise reasonable care during construction or work. If at any time damage or interruption to existing facilities shall occur, said other party is enjoined immediately to report such damage to the party owning such damaged or interrupted facilities.

The responsibility for the maintenance of necessary records to comply with this rule rests with the party owning or operating the facilities. Such records shall be available for inspection at all times by the Commission or the Commission's staff.

Detection Devices

Information recorded is usually based upon physical measurements from reference points with primary reliance being placed on two-dimensional measurements *assisted by* electronic locating devices *whenever usable.* In view of the limitations expressed above as *assisted by* and *whenever usable,* the need for accurate records is imperative. In some cities three-dimensional recording is required but is often excessively costly, unreliable, and misleading due to frequent elevation changes during placement to avoid interferences, irregularities in boring, and subsequent changes in surface grade.

In its present state, the art of locating underground utilities by detecting devices is not yet developed enough to justify placing exclusive reliance on this method. Mr. Charles A. Morse, Staff Manager, Pacific Telegraph & Telephone Company, has classified the present devices as follows:

1. Electrical conduction devices;
2. Electro-magnetic induction devices;
3. Electro-magnetic reflection devices (radar); and
4. Acoustical devices.

The present most widely applied device is electro-magnetic induction.

Detection systems may function in either a *trace* mode to follow the path of a known underground line or a *search* mode to discover any line lying under a selected route. The *tracing* capability is simpler to develop and has often been considered adequate in the past, but increasing complexity of the underground environment now makes the *searching* capability more necessary.

Detection devices most widely used today consist of a small radio transmitter and receiver with or without external antenna and signal output connections. All such devices radiate a very short range radio type of signal. Some devices radiate a signal only from an antenna which is an integral part of the instrument, (sometimes referred to as the *inductive mode*), while other devices connect to and radiate a signal from the plant sought (e.g., a buried pipe or cable). *Such plant must be an electrical conductor.* This latter type of usage is sometimes referred to colloquially as the *conductive mode* although this is a misnomer.

Figure 5, Downward-Looking Radar, is a photograph of one such instrument used for electromagnetic subsurface profiling.

Another class of devices consists of a separate transmitter propelled along a non-metallic buried conduit.

In all cases the device determines the presence of the buried plant by a chang in the signal returned to the radio receiver which is a part of the device.

Currently available types of equipment are:

1. Pipe and cable locators (*inductive* or *conductive* mode). Quite versatile.
2. Pipe and cable tracers (*conductive, trace* mode). (Some can measure depth.) Specialized purposes.
3. Metal locators (*inductive* mode). Less versatile than pipe and cable locators.

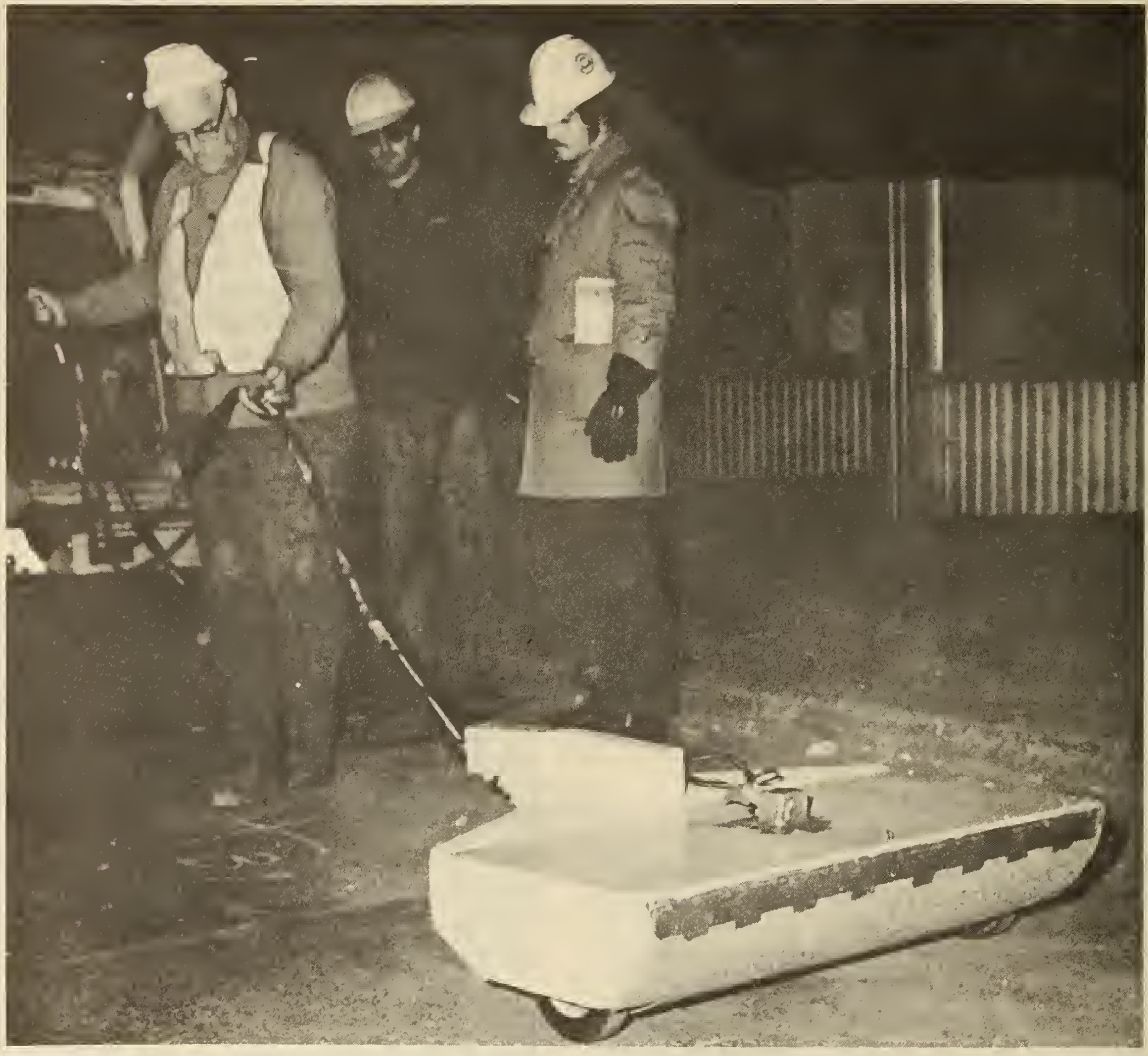
Another commonly employed method in waterworks practice is to drive rods through the ground until they strike (contact) the *metallic* pipe, then listen through an earphone receiver equipped with a metal prong attached to the diaphragm and held against the rod. Difference in sound as one progresses to the site of the leak becomes apparent. Operators gain considerable skill with this device after using it a number of times.

Considering the difficulties involved in location of plant and recovery it is apparent that the recording process is essential and particularly when risk of service interruption, the potential injury to the users of the service, and to workmen are considered.

Digitalized Computer Recording

Most utilities still take measurements and location of their plant by field measurements which are reduced to record form, books, cards and plans in the office by the design and drafting staff. With the increasing complexity of utility plant, better recording and retrieval methods must be adopted by both municipalities and utilities.

Over the past few years so much has been written about data processing, storage and



Source: *Telephony*, The Journal of the Telephone Industry, April 1973

FIGURE 5 DOWNWARD-LOOKING RADAR

retrieval by computers, and the field is so broad that it is not within the scope of this report to deal with the subject in any detail. More recent is the advent of the so-called computer graphics system or as it is sometimes called, an automated *drafting machine* system. This development will undoubtedly be of increasing importance to municipalities and utilities in the economical solution of their underground recording and mapping programs. An examination of such systems is therefore an essential consideration.

Traditional mapping work has been used primarily to locate and identify subsurface public utilities and municipal services in relation to surface geometry. Until now, the production of these plans, and their maintenance in an up-to-date and current state, required large amounts of highly skilled technical labor. This work has become increasingly difficult, particularly in the larger cities and the faster growing communities. The seriousness of the problem is demonstrated by the fact that major studies are being undertaken by such organizations as the Bell Telephone Companies both in the United States and Canada.

The existing mapping systems have many problems. The first, already mentioned, is the difficulty and slowness of updating the existing maps. However, the most serious defect is that no flexibility exists within the hand-drawn map system. Maps cannot easily be combined or changed in scale. Data and information from utility billing systems cannot be easily entered on these maps. In addition, it is difficult to capture statistics on, say, length of pipelines or other features of a particular system.

For the past few years, work has been carried on which clearly points to a solution to these problems. Military data handling technology has migrated into the private sector of the economy (technolgy transfer) and is finding useful and cost effective applications in the field of automatic cartography and the effective management of large amounts of machine readable information.

Three elements, developed in parallel for other purposes, have come together to make the development of an automated utility registry possible.

1. More powerful and less costly computer systems along with large capacity dynamic storage provide an economical means to process and store utility registry information.
2. Technological advances in electronic and electromechanical display systems can provide rapid and flexible means of display.
3. Radical improvements in aerial mapping techniques such as improved cameras, stereoplotters and related devices permit the translation of accurate models into maps suitable for nearly all urban purposes.

It is apparent that these techniques are cost effective *now* for the larger communities from about 150,000 population upwards, but the managers of smaller communities should realize that this technology will improve rapidly during the next several years and will become increasingly attractive in a labor market of constantly increasing costs. The managers of the smaller cities and towns should *begin now* to prepare a base for the introduction of these techniques beginning in, say, 1978 and beyond.

In 1967 the Public Utilities of Copenhagen, INTERCOM, started studies on an automated map drawing process and in 1969 the use of this system was routine. From 1968 onward the Direction de la Distribution d'Electricite de France, (French Electric Distribution System) Gas de France, (French Gas Corp.) and the City of Paris carried out studies of integrated data files for public utility and municipal service management.

In 1966 the (Canadian) National Capital Commission, Ottawa, Ontario, began studies of an integrated computer-based urban management system which would allow the use of data collected for one purpose to be used in utility management, for example, the forecast of demand. This work led to the creation of an automated property ownership map system (cadastral map system) and an automated topographic map system. These maps are routinely prepared and updates drawn by machine at scales of 1:600 to 1:1240 on a 3° modified transverse mercator system. Studies are being carried out for the purpose of relating utility location to this map base. A more detailed discussion of this particular system is given in Appendix D, National Capital Commission Information System.

Thus, it can be seen that the elements for an integrated automatic mapping system and data management system exist in an operational state. Let us now examine the advantages of these systems. First, and perhaps a central argument, is that the automation of utility and service maps is economical, a cost reduction per lot of 20 percent has been reported by one experienced user. It is possible to produce the final map in about 20 minutes, instead of a week or more using traditional methods.

Updating is also very rapid, and if desired, a new base map may be drawn. It is perhaps important at this point to remember that the *map* is a magnetic tape on disc, not the usual paper document. Because the *map* sheet is in automated form, modifications of scale are very easy, in fact the same map may be combined with other maps to form a smaller scale map of the entire community. The scale changes and map combinations can create small maps of the entire utility network. Because data and information are updated easily, statistics on the entire utility plant can be made available and be printed out or even annotated on the drawings automatically. Geographical data from other files, such as the location of each customer or large user, may also be added.

If this concept is carried further, it is natural to relate services and utilities to both property ownership maps and topographic and cultural detail. Figure 6, Samples of Machine Drawn Maps, shows various features which illustrate the flexibility and completeness of detail possible with these new systems.

So far the advantages discussed relate primarily to the administrative and clerical operations of the municipality or utility. However, because the written information on the maps is standardized and all maps have the same scale, e.g., gas, electricity, water, sewerage, cadastral, there are many on-site advantages. Inititally, no long investigations of the pipeline network and no local situation surveys are necessary before starting work. This not only reduces accidents on-site but greatly eases the problems of conflict and litigation between the various contractors and the contracting authorities. This is particularly true because each network can be shown in relation to the others or by itself and critical points can be shown in a different scale. Finally, profiles of the subsurface network may also be drawn if data, such as invert elevations, are contained in the file.

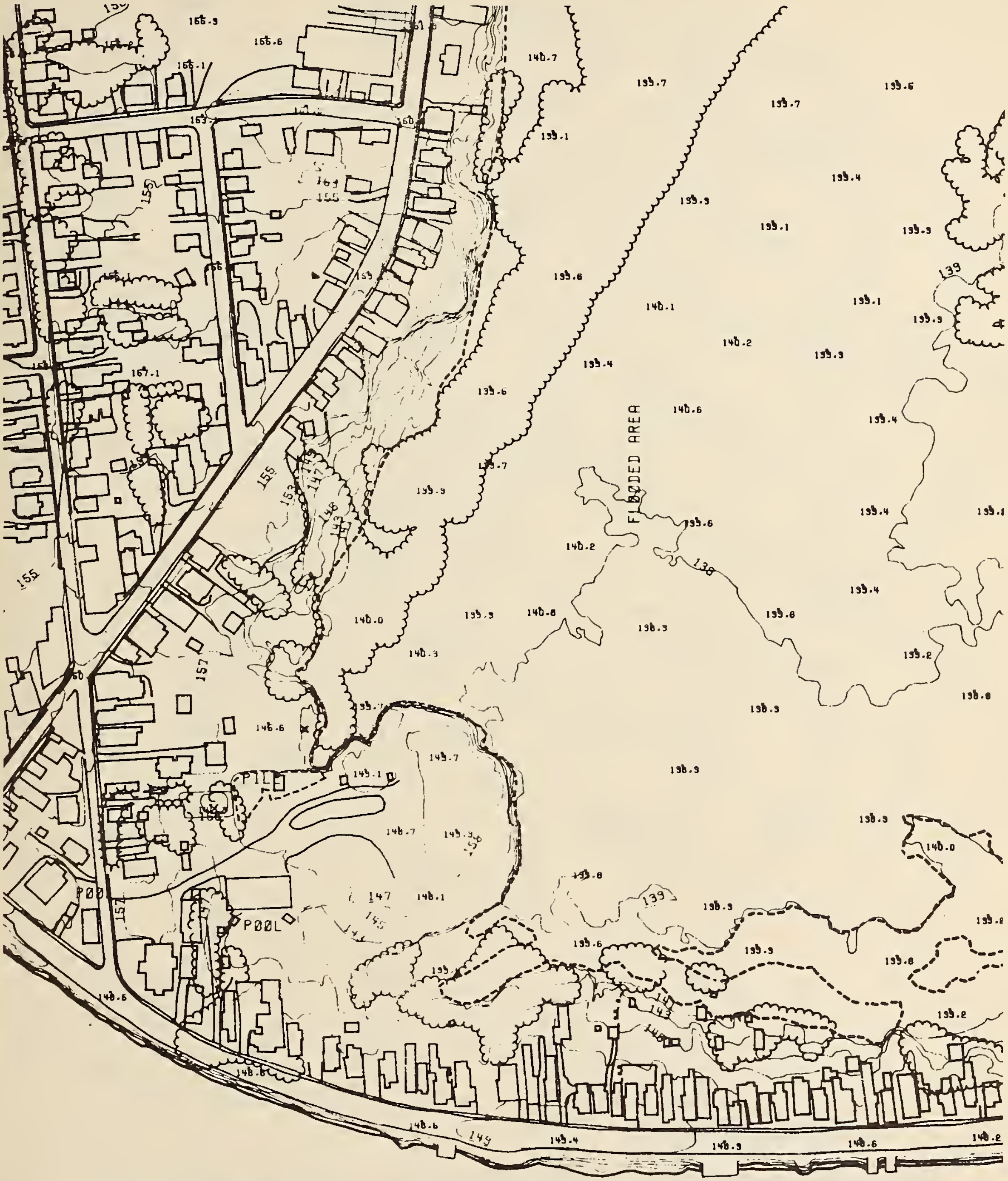
There are some disadvantages to these systems, however, but it should be stressed here that these disadvantages are *not* technical. Rather they are managerial. The introduction of a new system like the ones described above will mean a change in existing procedures and it is clear that the management of change is considerably more difficult than the management of a routinized on-going system. *A commitment by senior management, as well as a political commitment, is necessary if the venture is to be successful.*

Initially the development of this type of automated utility mapping system will be expensive. These high short-term (2-5 years) costs will be amply repaid in the long-term by a reduction in costs and higher staff productivity. These programs must be put forward on the basis of this long-term view not, as those programs which have failed, as a quick push-button solution to a difficult problem.

A limited potential computer graphics system is discussed in Civil Engineering (ASCE) February 1973. The system described is a limited potential representative system designed to carry out specific mapping tasks. The digitizer can operate off-line. Its output is recorded on cards, paper, tape or magnetic tape. Many owners have their in-house computer (e.g., IBM 1130) drive their plotter directly but as a plotter is relatively slow, the quicker computer is used inefficiently. Usually the plotting is carried out off-line with the plotter being driven by magnetic tape despite the fact that magnetic tape drives are relatively expensive to purchase ($15,000 used – $25,000 new). The Auto-trol digitizer is compatible with the IBM computer with drum plotter.

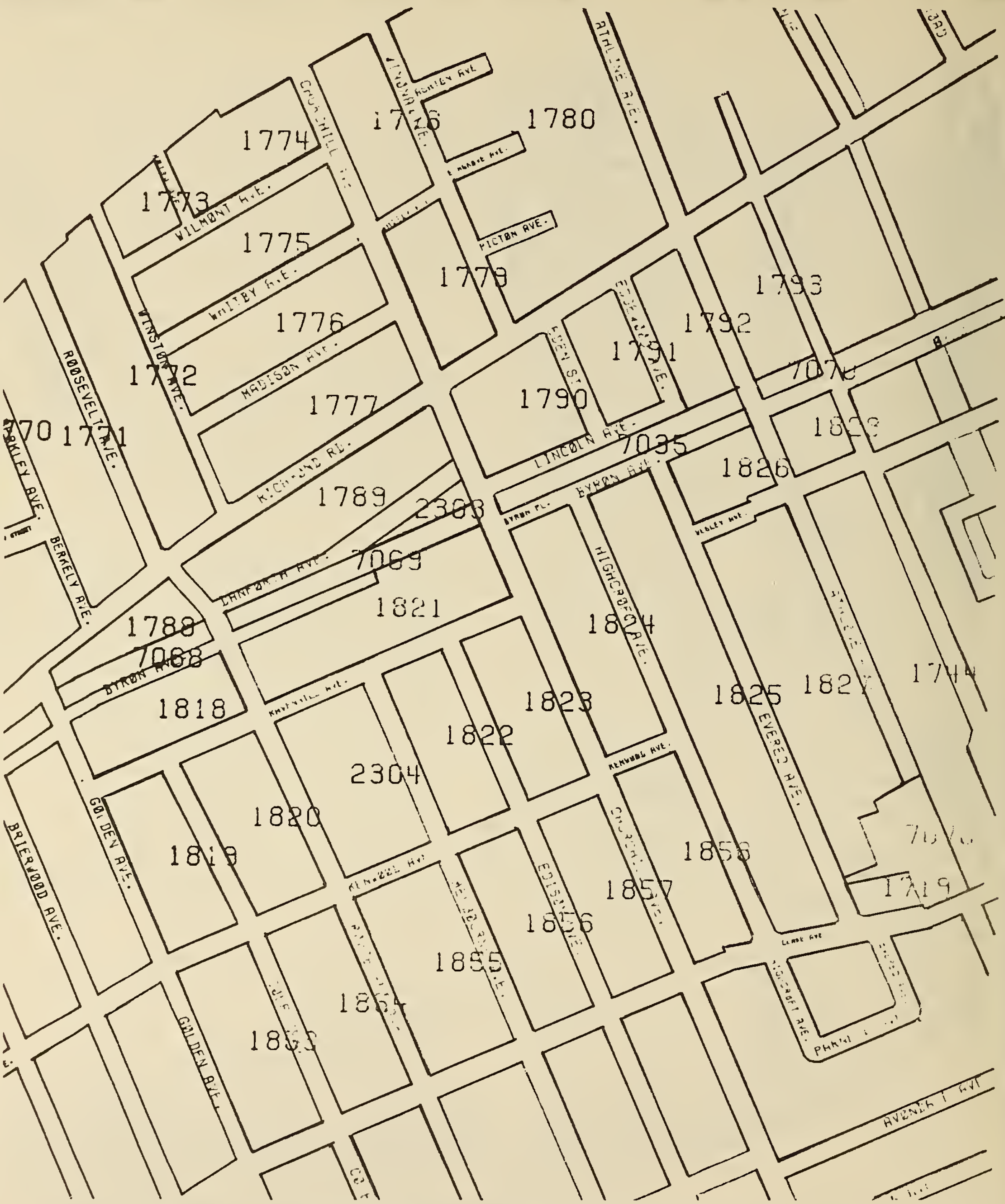
The leasing cost of the computer graphic system referred to above consisting of a Varian 620L-1200 (8k to 32k) computer; Auto-trol digitizer, teletype input-output, disc storage, Auto-trol flat bed plotter and magnetic tape read/write unit for recording drawings on tape is given as $2,200 per month, which amounts to 2.16 percent of the price of the system which calculates out to approximately $102,000. The digitizer alone is quoted to cost between $13,900 and $25,000 depending upon what is supplied. It may be leased at the rate of 2.16 percent of cost per month, which amounts to only $300 to $540 per month, an insignificant figure in view of today's high level costs.

The much more sophisticated system of the Canadian National Capital Commission,



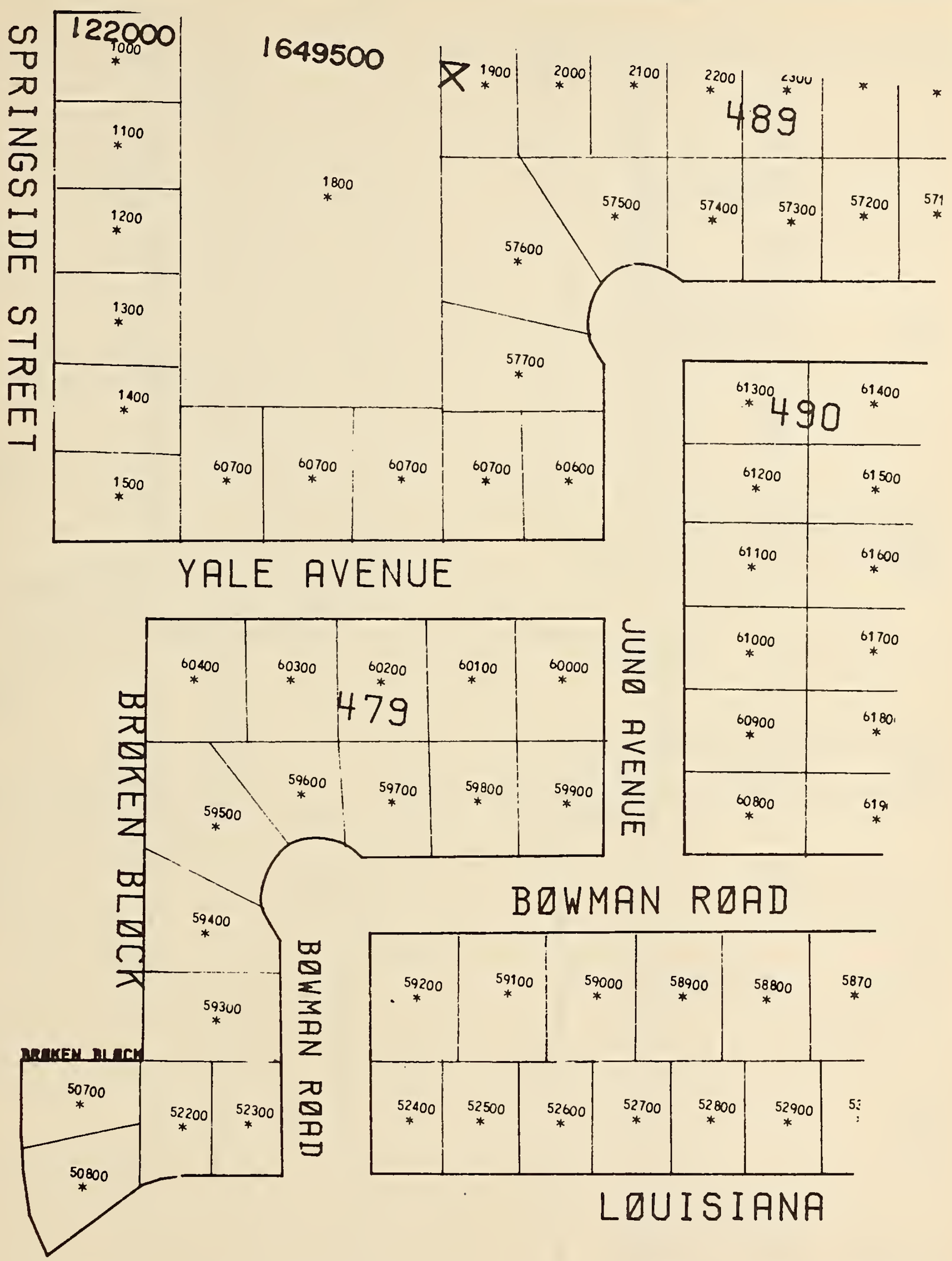
a. Section of unedited computer drawing showing typical urbanized area. Scale reduced by programme from 1:1250 to 1:2500. Reproduction shown here is actual size of 1:2500. Reproduction shown here is actual size of 1:2500 map. Approximate drawing time 18 minutes.

FIGURE 6 SAMPLES OF MACHINE DRAWN MAPS



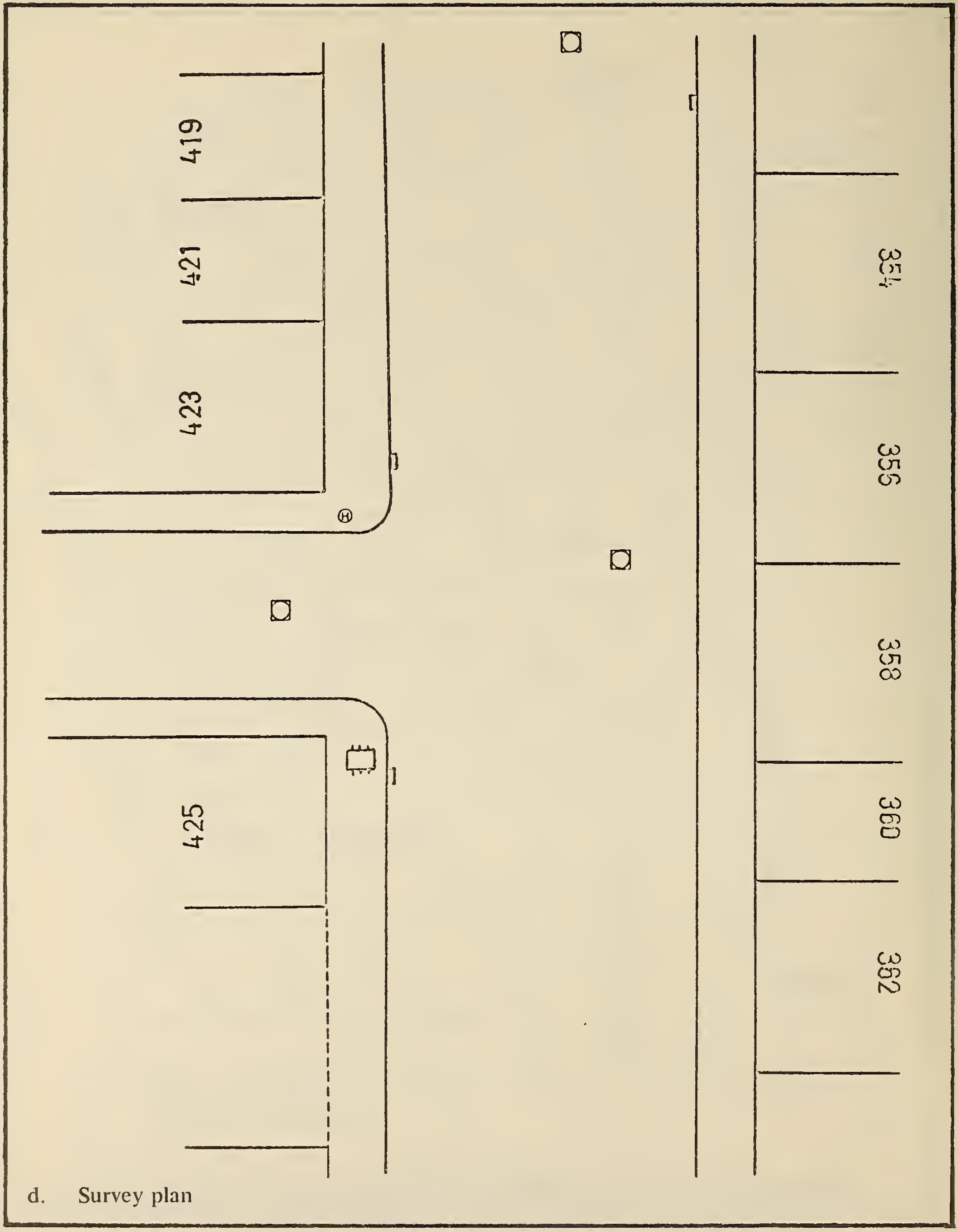
b. Section of block outline map, showing streets and block numbers. Scale 1:4800. Original was drawn in three colors, ink pen on paper. Approximate drawing time 10 minutes.

FIGURE 6 SAMPLES OF MACHINE DRAWN MAPS



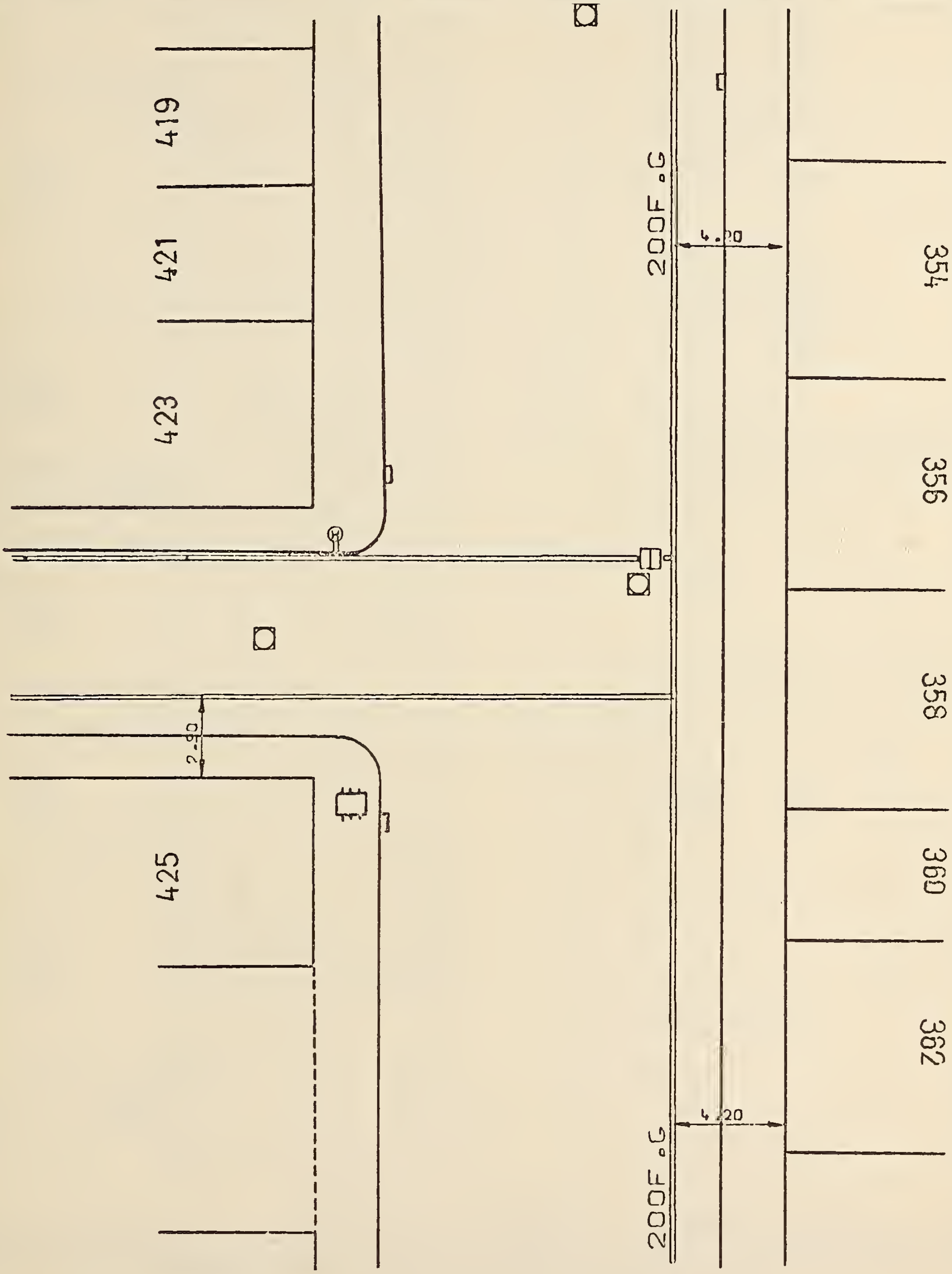
c. Section of 40 x 40 inch property ownership map. Reproduced at actual scale of 1:1200 map. 3 degree modified transverse coordinate control shown at top. Left side matches to adjacent map section. Assessment roll numbers shown as printed by plotter. Approximate drawing time three minutes.

FIGURE 6 SAMPLES OF MACHINE DRAWN MAPS



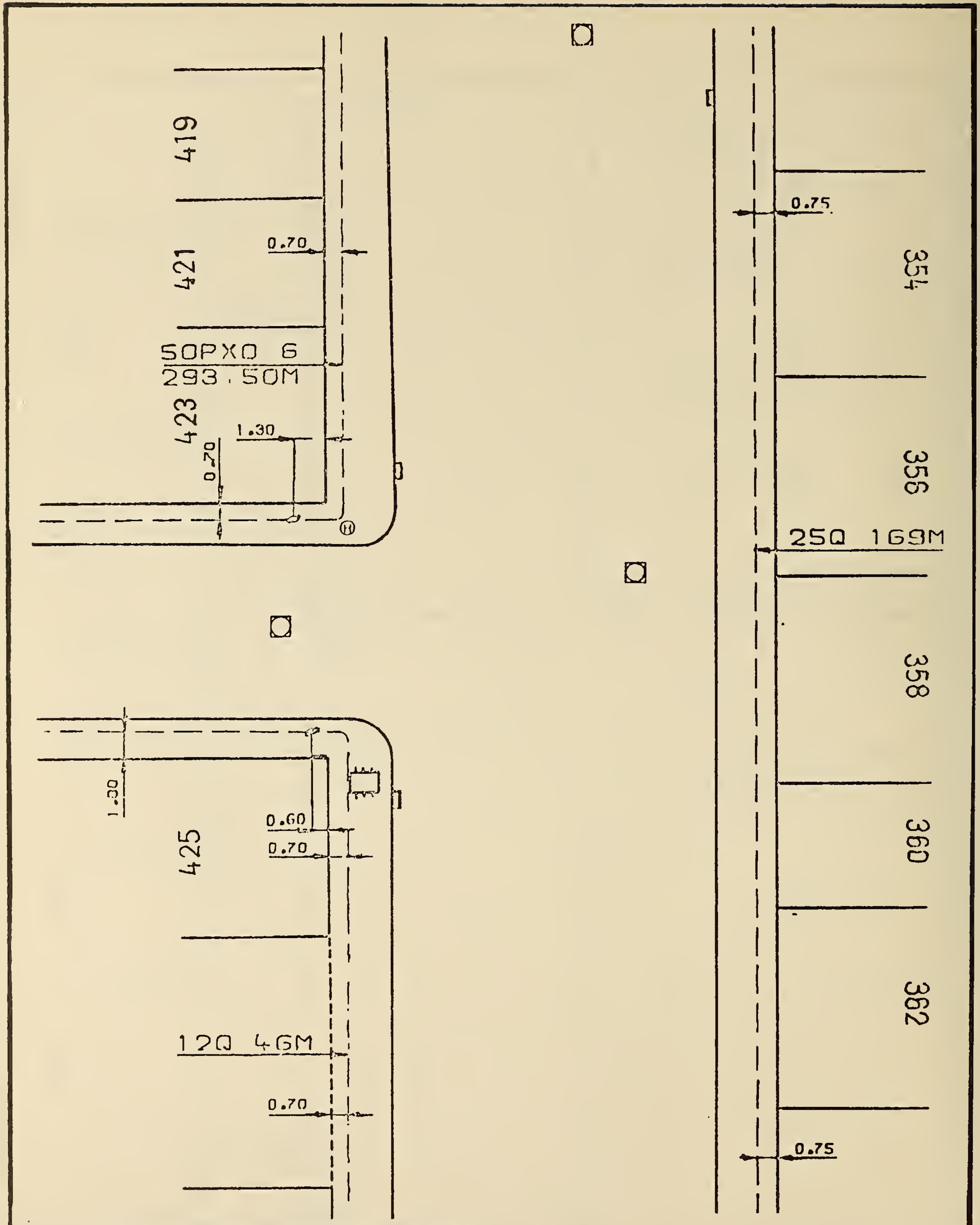
d. Survey plan

FIGURE 6 SAMPLES OF MACHINE DRAWN MAPS



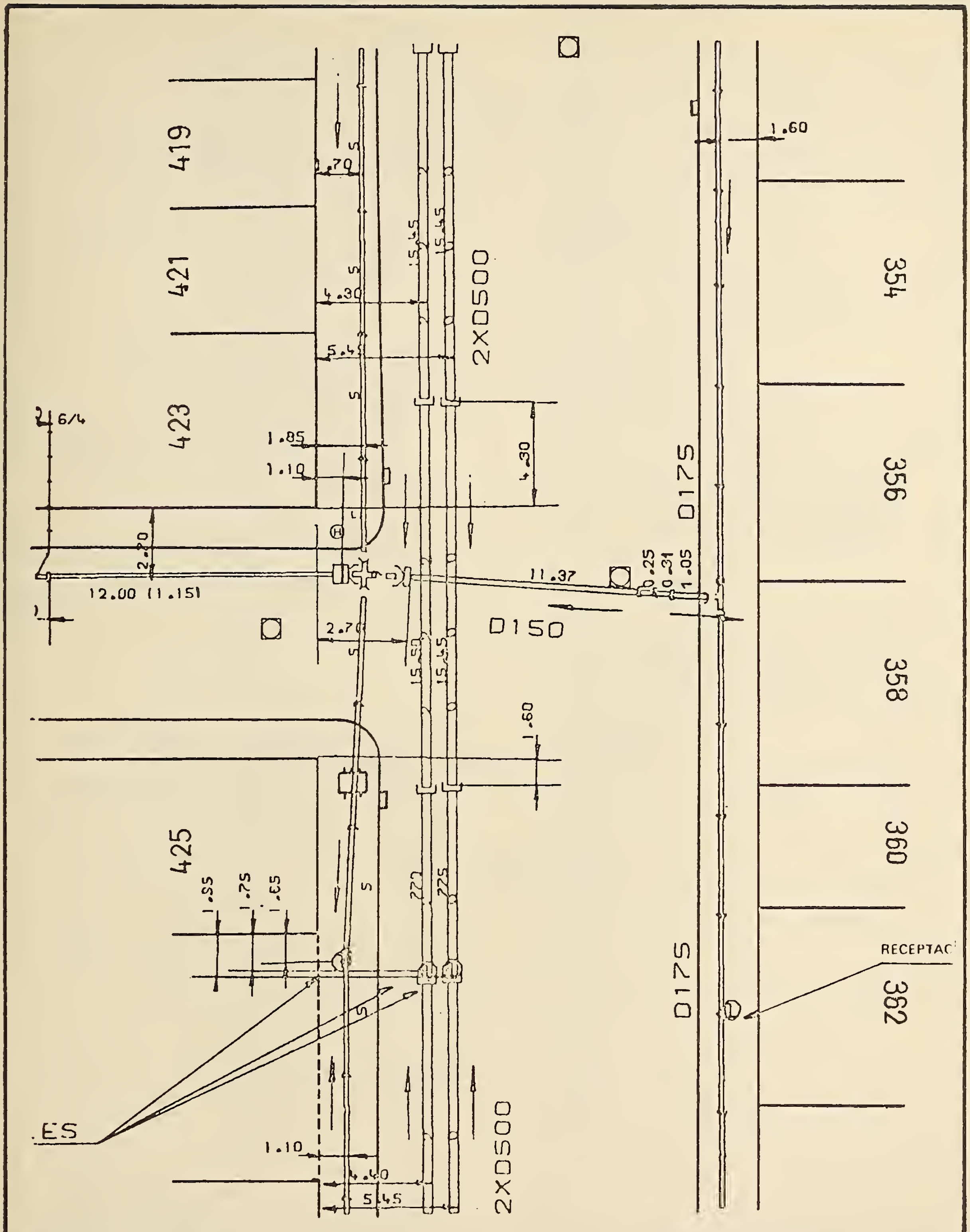
e. Survey plan, water

FIGURE 6 SAMPLES OF MACHINE DRAWN MAPS



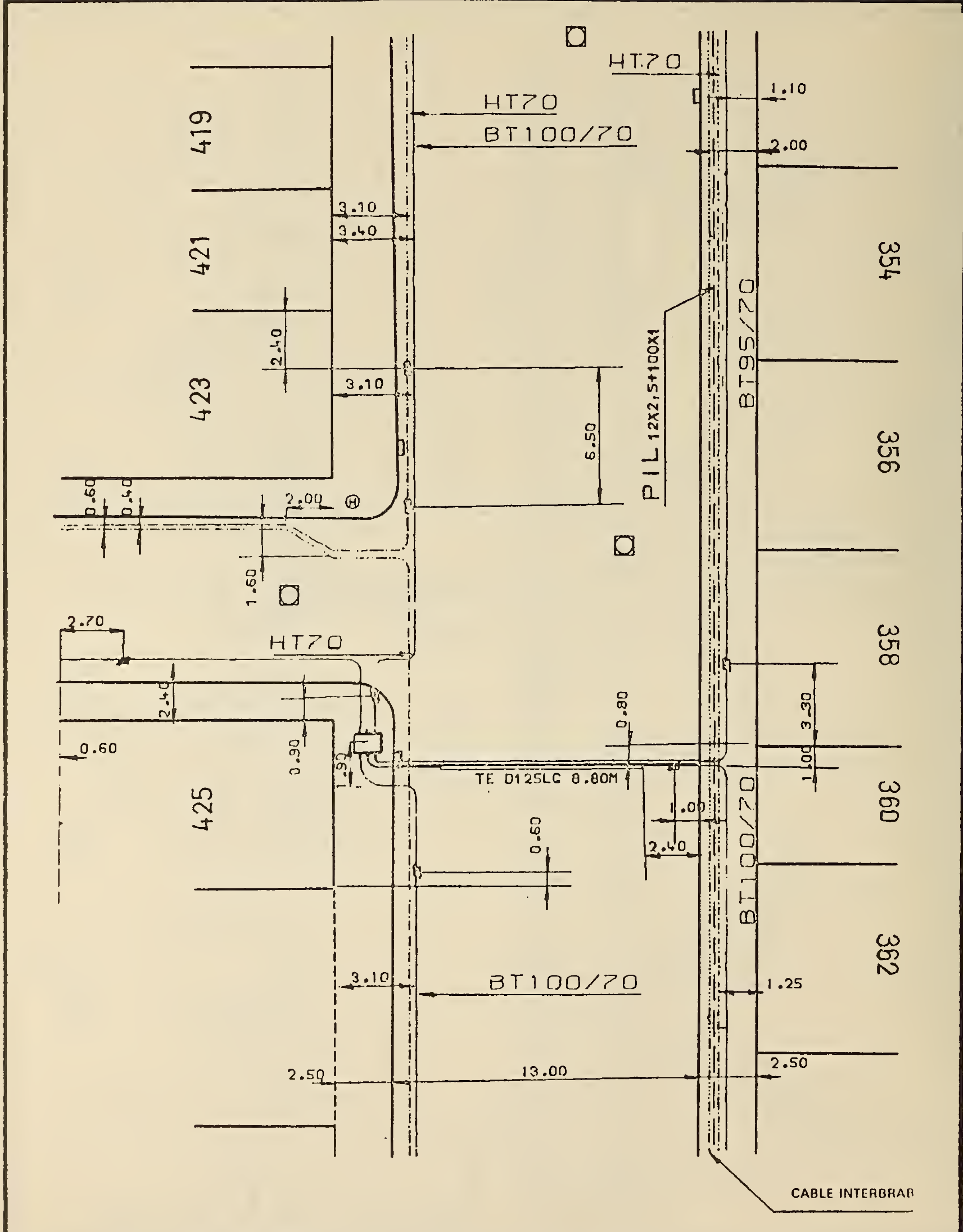
f. Survey plan, telephone and telegraph

FIGURE 6 SAMPLES OF MACHINE DRAWN MAPS



g. Survey plan, gas

FIGURE 6 SAMPLES OF MACHINE DRAWN MAPS



h. Survey plan, electricity

FIGURE 6 SAMPLES OF MACHINE DRAWN MAPS

Ottawa, may be simply described as an off-line Auto-trol digitizer, a 400/200 flat bed plotter (a 54 in. x 76 in. working surface), a Honeywell 6000 series computer with approximately 500,000,000 (50×10^6) characters of disc storage.

This computer handles both time sharing and batch processing and has a large potential for data management and retrieval. Systems of this magnitude lease for about $20,000 per month – an amount that should not frighten the larger cities and larger utilities and metropolitan areas.

Acknowledgement is made to Mr. D. L. McDonald, Assistant General Manager and to Mr. D. C. Symons, Assistant Director (Computers) respectively of the National Capital Commission, Ottawa for assistance in preparing the preceding material.

Mr. Herbert G. Poertner, formerly of the Research Foundation of the APWA, lists the following benefits and advantages of Computerized Information Files in the management of utilities. He states in APWA Report No. 39, dated February 1971, entitled Feasibility of Utility Tunnels in Urban Areas:

The benefits and advantages anticipated are:

1. *Computer mapping of utility distribution lines, consumption, etc., becomes routine by interfacing the computer with an automatic drafting machine. Other data, such as building permit records, accident records, etc., can be summed and computer-mapped for specifically selected geographic areas.*
2. *Computerized geographically based information files will provide quick access to current input data needed for making utility network analyses and load/demand forecasts.*
3. *Maintenance and replacement program planning and budgeting can be based upon accurate, complete and readily available data.*
4. *Inventories of installations can be made accurately and rapidly.*
5. *Utility replacement and construction programs can be better coordinated with street improvement needs and priorities to reduce the frequency of street cuts and traffic disruption.*
6. *Rapid access to accurate information concerning the location of utility distribution lines and facilities can expedite construction, maintenance and relocation of utility services. It can also reduce the frequency and cost of damage arising during construction and demolition work.*
7. *The information files can be used in planning for utility plant and distribution needs, as well as for transportation, health, law enforcement, schools, housing and zoning.*
8. *The street file can be used to help determine optimal routes for constructing utility distribution lines, as well as refuse collection, street sweeping, snow plowing and emergency vehicles.*
9. *All urban data records stored in the system files can be interrelated by geographic location. Thus, utility records can be interrelated to demographic records, income-level records, building and demolition permit records, etc.*
10. *The geographic base files can supply a control framework for a land-use inventory, of use to planning departments and utility companies.*
11. *The files can aid in specifying area aggregations for special census tabulations of the basic record data on individuals and housing units.*
12. *Substantial benefits to utility companies and local public agencies can result from implementation of computerized management information systems, based upon a coding system for geographical location of utility distribution lines, both underground and overhead, and other physical features of urban areas.*
13. *Utility information retrieval is merely one aspect of the overall management information needs of an urban area, and this suggests that any systems that are developed should be compatible with and easily incorporated into broad data-base systems – to permit correlations to be made of the city's physical features and socio-economic factors.*

Conclusions

Information management in large urban areas can be enhanced and expanded through the development and implementation of broad computerized information files designed to relate facts to their geographical location and street address, to permit retrieving data concerning local physical features and correlating these with selected socio-economic data of the particular area. The *street* master file can include utility-type records as well as records of street pavements, sidewalks, curbs, street lighting, traffic density and signalization, refuse collection, landscaping, fire alarms and hydrants, police telephones, parking meters, air raid sirens, etc. Data concerning the parcels of property, buildings and occupancies bordering the streets can be developed into a *parcel* master file. A third possible file is a *people* file.

If one examines the information needs of public utility companies and water and sewer departments of local governments, it becomes apparent that information is needed beyond that of mere identification, description and geographic location of utility distribution lines and facilities. Ready access to such inventory-type data is desirable but it constitutes only a portion of the total information needed for planning, designing, financing, budgeting, constructing, operating and managing modern public utility systems. Much of the needed data must be obtained from sources outside the public utility company or city engineering department. This emphasizes the need for adopting information retrievals systems which are broad and compatible with the systems of record-keeping adopted by various city departments, local and metropolitan governments and utility companies, as well as state and federal bureaus and agencies.

CHAPTER VIII
LOCATION PRACTICES AND STANDARDS

Regulation by government, and helpful cooperation-coordination of utility installation and modification work, will not, of themselves, assure optimum utility location practices. In fact, much of the thrust of regulation and give-and-take co-partnership has been invoked to make the best of a difficult right-of-way space accommodation problem in many older communities. What has long been needed is a plan of action for utility locations in the right-of-way, with pre-determined positioning of each utility in the underground space and adherence to such a basic blueprint, but with reasonable and rational variations to meet local conditions.

Many local governmental agencies have adopted standards of utility location in recent years. Standards covering various right-of-way widths, patterns of sidewalks and roadways, use of center malls, and other conditions have been developed. A problem with these well-meaning standards is that they are often inapplicable and unattainable in street areas where existing utilities are seriously crowded and where it would be infeasible to expect major or dramatic reorientation of the underground. The location criteria covered by such standards are more practical and applicable in new developments, in urban relocation work, and in cases where overhead facilities are being converted into underground structures and plant.

UTILITY AND LOCATION CONSTRAINTS

Because of the indeterminate nature of policies in individual communities and the almost complete lack of city-to-city uniformity of practices, it is dangerous and misleading to apply definitive conclusions to an indefinite subject. It is appropriate, however, to examine the actual utility location conditions and practices in the 222 communities covered by the mail survey in the current study.

"Mail survey" utility locations are affected, as has been indicated, by the width of rights-of-way and pavement areas. Table 11, Right-of-Way and Pavement Width, lists the average widths reported.

TABLE 11
RIGHT-OF-WAY AND PAVEMENT WIDTH

Type of Street	Right-of-Way Width (feet-avg.)	Pavement Width—curb to curb (feet-avg.)
Central business district	76	53
Principal arterials outside CBD	82	55
Minor arterials	68	43
Collectors	64	40
Industrial street	65	40
Older residential streets	55	30
Newer residential streets	56	32
Public alleys	19	--

Source: Survey of 222 agencies, 1973 by APWA

The perception of the local public works officials as to the adequacy of existing rights-of-way for the accommodation of existing and projected utilities, considering necessary clearances, was explored. Table 12, Adequacy of Right-of-Way Width, reports the findings.

TABLE 12
ADEQUACY OF RIGHT-OF-WAY WIDTH

Type of Street	Adequacy of Right-of-Way Width			
	Existing Utilities		Future Utilities	
	Yes	No	Yes	No
Central business district	82%	18%	54%	46%
Major arterials	89	11	72	28
Industrial arterials	93	7	83	17
Older residential streets	88	12	73	27
Newer residential streets	98	2	93	7

Note: This tabulation does not necessarily represent the views of either public or private management, but rather that of the permit agency.

Source: Survey of 222 agencies, 1973 by APWA

Field Survey

The reported adequacy of underground space was not fully borne out in the field studies. One facet of the mail survey matched the field findings – the lower degree of adequacy to meet future utility growth.

- In Baltimore, despite many reasonably wide streets in the CBD, arterials and some residential streets, the adequacy of right-of-way widths is classed as inadequate, even for today's utility needs. Adequacy in industrial areas and newer residential sections is far more demonstrable. In Baltimore County, rights-of-way are now considered adequate but future growth will tax accommodation capabilities.

- Streets in the central zone of Boston are narrow, winding and hilly. Any attempt to change the complex profile of the congested downtown streets will be complicated by narrow sidewalks, buildings that crowd property lines and the rolling terrain. The suburban community of Brookline, Massachusetts, provides more adequate right-of-way space for underground utilities. While the central business district is less commodious, the town's growth has reached almost zero-level and future impediments to utility locations will be no worse than today's condition. This no-growth condition is not the urban norm but many communities have little open area available for new subdivision developments and thus, cannot easily provide better utility location practices to improve on conditions in their unplanned older areas.

- Columbus, Ohio, and its satellite suburban community of Upper Arlington, are examples of metro areas where underground utility space is not yet a serious problem because plant is now predominantly overhead.

- In Des Moines, present utility right-of-way accommodation capabilities are classed as adequate because of wide street layouts in the central city, but secondary business areas are narrower and more congested and older residential areas are already tight. Future utility needs may tax available space.

- Atlanta's streets now provide reasonably adequate space for accommodating underground utilities and future needs are assured by the city's consideration of utility requirements when it acquires rights-of-way for new streets. Considerable difficulties are anticipated when new utilities are required in roadways in areas where additional right-of-way widths are not attainable.

- Ottawa, Ont. , offers an insight into the relationship between right-of-way widths and the future problems of utility accommodation. The space versus need balance is deemed satisfactory at this time by city officials but the future is in doubt. Developers are urging elected officials to reduce street width requirements because of the high cost of land. The regional government, on the other hand, has set 86-foot rights-of-way as a minimum, with 100 feet as minimum on major streets; the Province of Ontario's Ministry of Supply and Transportation will not contribute to maintenance and upkeep of roads if these minima are not provided.

- In Montreal, the space situation is critical in the areas immediately surrounding the central business district but not troublesome elsewhere in the city. Future utility accommodation conditions are expected to worsen. The development of the city's ducting system, described elsewhere in this report, has been of great value in preventing and correcting right-of-way crowding.

The adequacy of existing facilities was reported as high in all types of streets, but this adequacy will be taxed by needs for future underground plant. This reported adequacy for existing utilities can be interpreted as simply that the underground units are in place, they are "not going anywhere," and therefore the space is "adequate" although space for maintenance activities may be lacking. Since future needs may require more right-of-way space, the survey explored how such added width could be acquired. Currently, such acquisitions are made in only about one-half of the reporting communities, predominantly to meet the needs of municipal utilities but also at times to provide added space for all utilities. The survey indicated that further right-of-way acquisitions are never made in 47 percent of the respondent cities for all utilities – privately- and publicly-owned – and rarely in another 47 percent of the respondent operations.

Street intersections can impose the greatest strain on the space for accommodation of utilities in the right-of-way. In fact, the "Chinese Wall syndrome" – the problem of getting across deep ducting structures with other utilities, to serve cross-street purposes, can be felt most seriously within intersections. The mail survey disclosed such intersection utility accommodation problems for new service plant. Eighteen percent of respondents reported considerable problems of this nature in many locations; 30 percent experience considerable problems at some locations; 21 percent have moderate problems of this type. No problems were reported by only three percent of the mail survey communities.

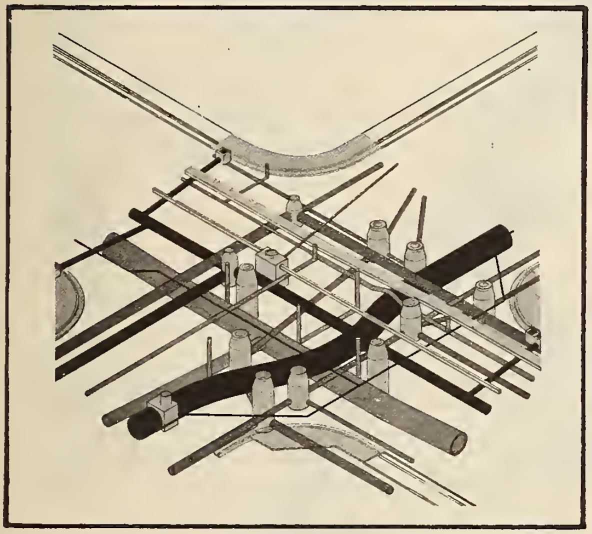


FIGURE 7 INTERSECTION OF TWO ARTERIAL STREETS – 7TH AVENUE AND INDIAN SCHOOL ROAD, PHOENIX, ARIZONA

Figure 7, Phoenix, Arizona 7th Avenue, is a schematic drawing of the complexity which may be found in even an area miles removed from the CBD. Figure 8, San Francisco Market Street, indicates the complexity of utilities in the CBD of an older city.

The trend toward enactment of utility location guidelines or standards was demonstrated by the survey data. Forty-one percent of the communities have some form of utility location goals; 21 percent more are working on such criteria; and 38 percent have made no moves in this direction. However, the intent of the provisions is not as clear-cut as the trend data might indicate. Of the communities which are trying to establish uniformity of practice, 31 percent make compliance with standards mandatory and 69 percent merely look upon them as guidelines toward suggested location criteria.

Since uniformity of location of specific utilities in specific points in the underground must be the ultimate goal of any standards of practice, it is of interest to know if communities gain compliance with such optimum patterns. Fifty-four percent reported considerable uniformity of locations throughout their areas; 33 percent obtain usual normalcy in the same location for the same utility; and 16 percent have no patterns and utilities can be located anywhere they please.

Utilities cannot be expected to revise existing plant as to location or depth solely or primarily for the purpose of creating uniformity. However, when new or relocation work is undertaken, uniformity should be sought.

It is acknowledged that the present may be "locked in" because of the past, but what of future prospects for uniform utility location practices? A minimum number of communities reported utility planning programs or master plans for all utilities; 57 percent have projected such planning for municipal utilities only; and 37 percent have no look-ahead policies or plans. In the communities where utility planning on the basis of a master plan is in effect, 83 percent are involved in making projections of future utility needs; 88 to 90 percent base their planning for major lines and their sizing; 44 percent translate future needs in terms of right-of-way requirements. Planning is coordinated with all public and private utility companies – 32 percent; with street and utility improvement plans and schedules – 58 percent; and with land use control concepts – 41 percent.

Utility location standards are dictated, in great measure, by the normal depth of cover of the specific lines, climatic conditions, geological phenomena, the freedom to vary vertically and horizontally from firm and rigid layout lines and whether services depend on gravity flow gradients, such as in gravity sanitary sewers, storm sewers and combined sewer lines. The mail survey explored the typical minimum depths of burial for utilities in the right-of-way; the results of which are presented in Table 13, Minimum Depth of Burial.

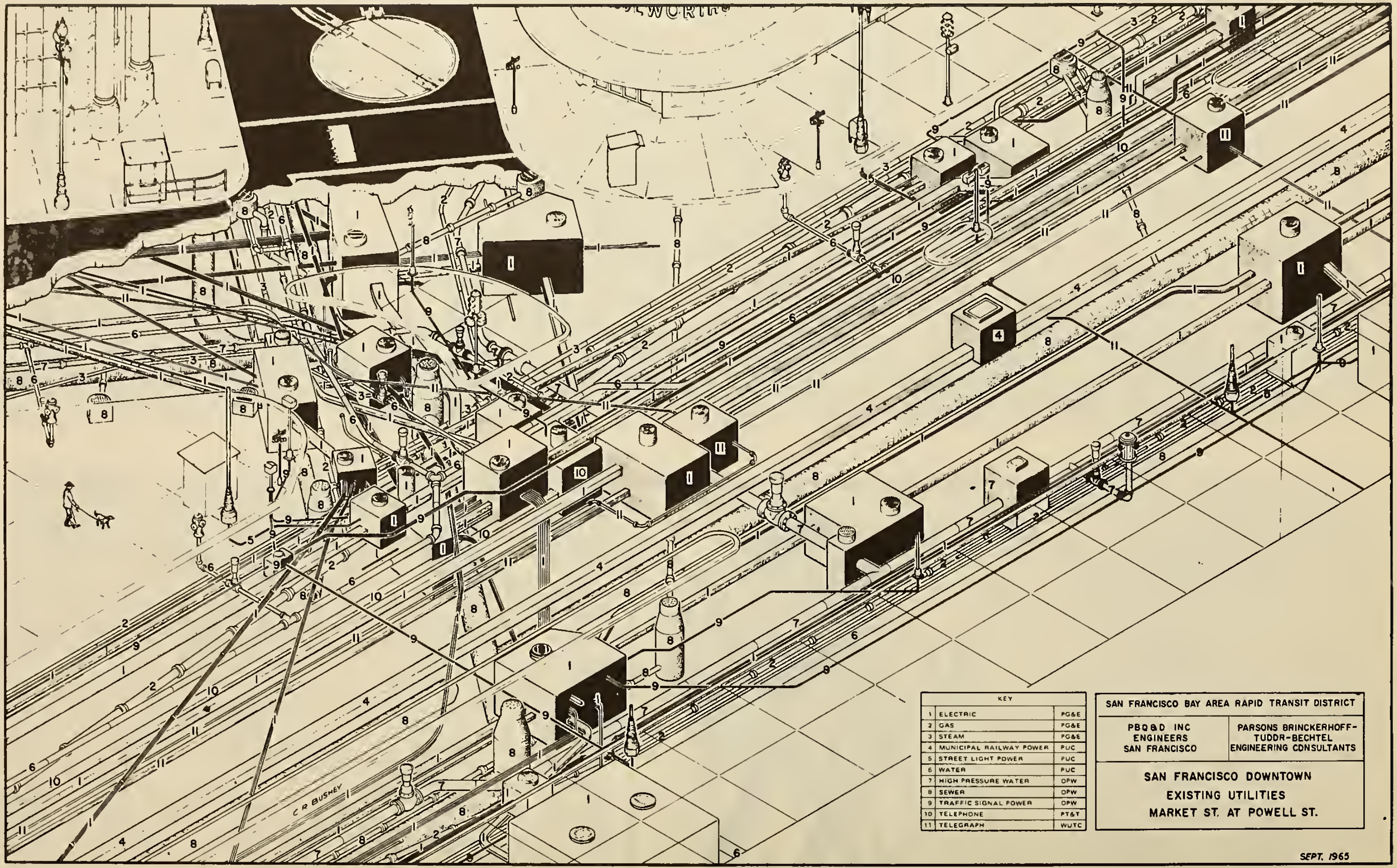


FIGURE 8 PHANTOM VIEW OF SUBSURFACE UTILITIES AT LOCATION OF SUBWAY STATION AND TUNNEL, BAY AREA RAPID TRANSIT SYSTEM

TABLE 13
MINIMUM DEPTH OF BURIAL

Utility	Most Frequent Reply Cover (in.)
Water mains	42
Sanitary sewers	60
Storm sewers	42
Gas	29
Electric	28
Telephone	26
Telegraph	26
Cable TV	26
Street lighting	23
Traffic signal	24
Police and fire	24
Steam	34
Chilled water	30

Source: Survey of 222 agencies, 1973, by APWA.

Another major practice which influences location and space needs is the desire of use of dual distribution systems to minimize street crossings of service connections. Table 14, Use of Dual Distribution Systems, indicates that about 40 percent of the surveyed utilities use such systems.

TABLE 14
USE OF DUAL DISTRIBUTION SYSTEMS

Utility	Yes (%) Widely Used	Yes (%) In Some Cases	No (%)
Water	5	38	57
Sanitary sewers	4	40	56
Gas	7	30	63
Others	13	30	57

Source: Survey of 222 agencies, 1973 by APWA

There are several types of physical constraints which play a major role in determining the location of utilities. Among these are alley systems; street trees; median landscaping; major items of street furniture; utility required encroachments, such as pipes, ducts, posts, service vaults, elevators and storage space in the right-of-way.

Wherever alley systems exist, full utilization of their potential should be gained. Many alleys have been used for overhead plant and conversion to underground can take place within the same right-of-way, if the governmental agency requires that provision for ducts is made in any underground space use which is allowed, such as parking garages or store-to-store connections.

Street trees may effectively make it unfeasible to use the parkway section. Either the presence of the trees will limit construction, or the root system of the trees may create maintenance problems. In a similar manner, landscaped medians may limit that section of the right-of-way for economical consideration for placing utilities.

Such limits to utility placement, although objectionable within the context of this report, are not necessarily bad because of the desirable aesthetic value which such features provide.

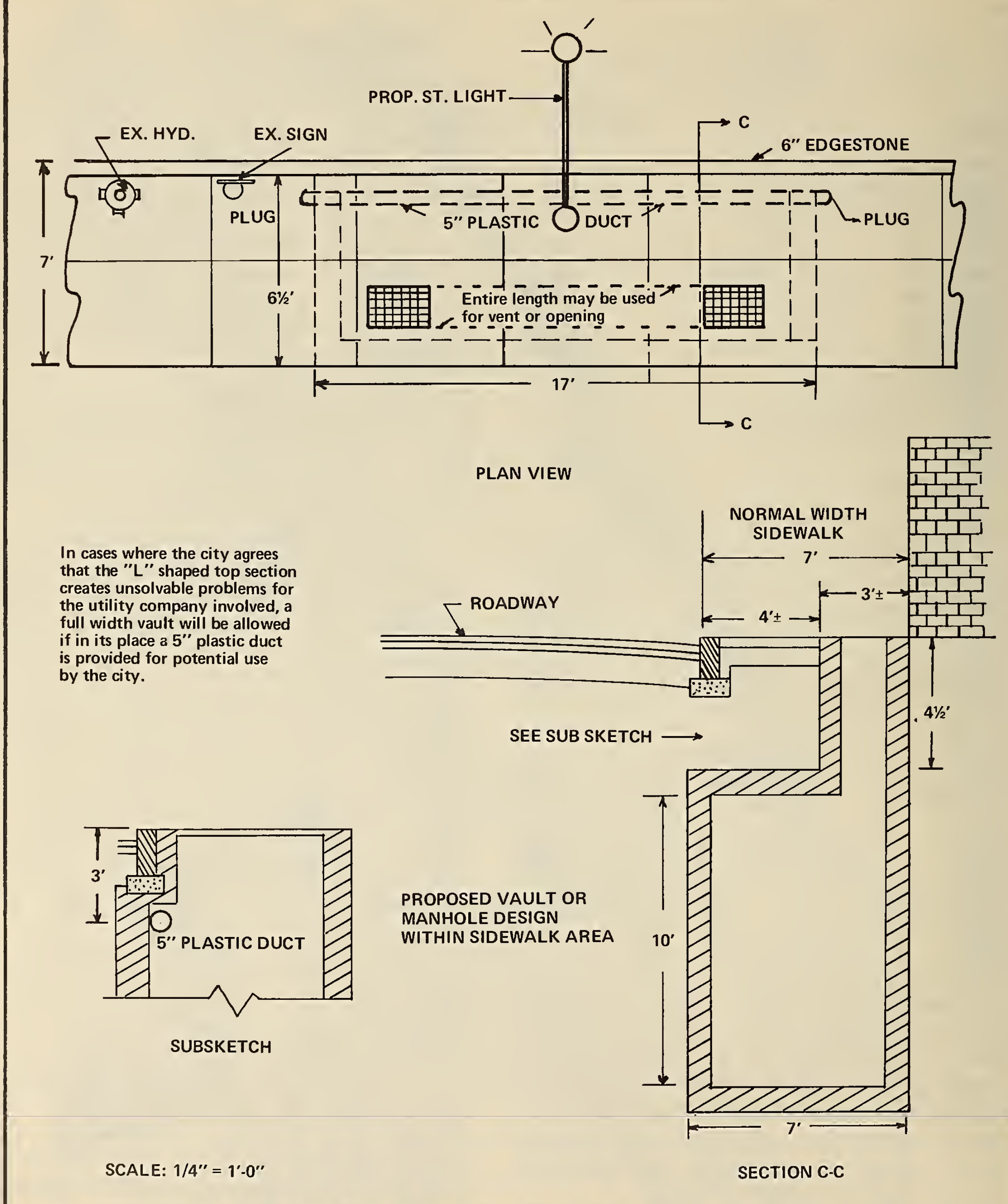
A solution for street tree problems which has been used is to secure a right to plant trees outside of the right-of-way. Aesthetic needs and utility requirements were met at the same time by such a program.

Utility required vaults, when allowed in the right-of-way, effectively blank out major portions of the available space. A recent study in Chicago, Ill., of a street in the CBD indicated that such vaults were a major restraint in the planning for relocation of utilities. However, it was found that many of the vaults could be moved into the building which they served, and that others could be redesigned to parallel the building and not be so deep as to prohibit other use of the space. Figure 9, Proposed Utility Vaults, Boston, Mass., shows the design which was developed to allow utilities to continue to use the sidewalk space.

In a similar manner, portions of an underground transit system must also be accommodated. Ventilation shafts, access points and such, physically block major portions of the right-of-way.

In a similar manner where inadequate delivery facilities have been allowed and storage and elevator space within the right-of-way allowed, public space cannot be used. Such encroachments should be removed as opportunities become available.

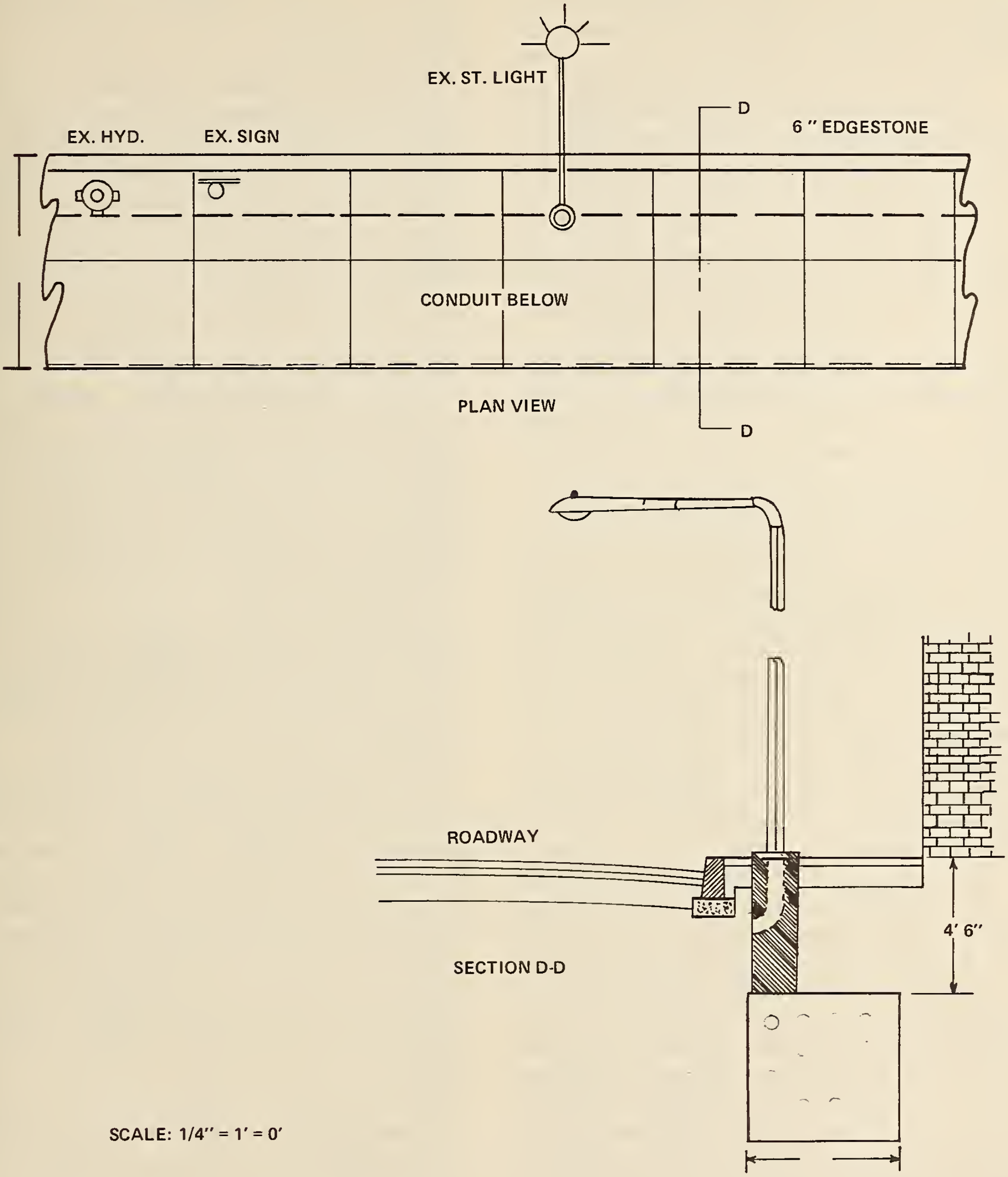
Finally, in some areas the presence of irrigation ditches or pipelines can be a major problem. The systems may very well be private and have well established rights. Appurtenances such as boxes and gates require additional area. As such systems operate by gravity flow they offer little



In cases where the city agrees that the "L" shaped top section creates unsolvable problems for the utility company involved, a full width vault will be allowed if in its place a 5" plastic duct is provided for potential use by the city.

a. Proposed vault or manhole design within sidewalk area

FIGURE 9 PROPOSED UTILITY VAULTS, BOSTON, MASSACHUSETTS



b. Proposed conduit location in sidewalk

FIGURE 9 PROPOSED UTILITY VAULTS, BOSTON, MASSACHUSETTS

flexibility in location. Relocation or upgrading can only be done during the period when the system is not in use.

Leapfrog development in irrigated areas is a particular problem where the irrigation system, both supply and drain or return ditch, must be maintained by landowners who no longer have use of the facility.

Since current utility location practices have a great bearing on future policies and procedures, the field investigations of a score of metropolitan central cities and fringe area suburban communities sought information on the present state of the art, reasons for it, and the trends and developments which offer to convert the "art" into a more exact *science* of utility location in modern rights-of-way.

OVERHEAD VS. UNDERGROUND

One of the most significant facets of current utility accommodation practices is whether communities are served by overhead or underground wire facilities, over and above those plant items which are of in-the-ground character – water, sewers, gas, steam and chilled water. Where overheading is still predominant and undergrounding will be practiced voluntarily or under edict in the coming years, the communities have the opportunity to set programs and standards for these conversions.

Baltimore has catalyzed undergrounding by providing a municipally-owned ducting system, yet overheading is still very much in use. As stated elsewhere, the city has never consummated the total undergrounding of utilities ordained by legislative action in 1898 when the duct program was authorized. It does, however, require undergrounding where ducts are available, either in the city conduits or in private ducts, as the telephone utility has chosen to provide. In 1969, the State Public Service Commission ordered utilities to place all new building services underground in development areas; this mandate has been firmly enforced.

Baltimore County is essentially overhead country, with a few of the central areas undergrounded. Wtihout the inducement of ducting which the parent city provides, there is not the inducement or the requirement for utility conversion and the private firms have chosen to stay overhead. New realty subdivisions are required to provide underground services.

Privately-owned utilities are not compelled to underground their facilities in Boston but much of the central district is undergrounded, not by compulsion but by voluntary action, often dictated by public desire, aesthetics and persuasion of government officials. The outlying areas are frequently overheaded; even new subdivisions are not required to use underground utilities. A state permissive law offers local communities the right to require undergrounding but neither Boston nor Brookline have invoked this type of legislation, because conversion would impose undue costs on the property owners to meet new service entry locations. Both electric and telephone utilities in Brookline are approximately 25 percent underground and 75 percent overhead.

Columbus, Ohio, utilities are located primarily overhead. The telephone utility was reported as more apt to underground than the electric utility but the actual location summary in the city does not fully bear out this generalization. Both telephone and electric lines are overheaded approximately 85 percent of the time. Here, again, the suburban communities parallel the practices of the central city. Upper Arlington's electric utility lines are 95 percent overhead and its telephone services are 80 percent overheaded. Subdivisions are often served by underground utilities – not by compulsion but in compliance with the desire of developers and arrangements made between them and the utilities.

The absence of authority to require undergrounding resulted in an unusual arrangement with the electric utility when Upper Arlington constructed its Municipal Service Center in an attractive mall area. The city wanted to clear all overhead wires in the area; telephone undergrounded its lines to meet the city's request; the electric company demurred because of the high cost of conversion. Consequently, the city paid the total cost of undergrounding the power lines in the mall sector and granted the utility a 10-foot easement outside the regular right-of-way at no cost in order to eliminate unsightly wire conditions.

In Des Moines, a 1968 ordinance required undergrounding in the central business district, but conversion has not been intensively pursued. In the secondary business district, 40 percent of utility lines are underground, with telephone predominant. Undergrounding is the rule in urban renewal areas, and it is required by ordinance and enforced in new subdivisions. Older residential areas are still interlaced with overhead wires. City aerial street lighting services and the police alarm system are now being phased out and placed underground. In the suburb of Urbandale, electric and telephone service lines are generally overhead.

Utilities in Atlanta's central business district are placed underground, as they are in new subdivisions. A mixture of overheading and undergrounding is in effect elsewhere in the city but there is a voluntary trend toward going underground with existing utilities whenever the occasion for conversion arises.

In 1973, the City of Los Angeles adopted a procedural ordinance for the formation of undergrounding districts in conformance with the California Public Utility Commission directions (Case 8209). A Technical Advisory Committee, under chairmanship of the city engineer, recommends boundaries and provides technical reports on proposed districts.

In Austin, Tex., undergrounding is not mandatory in subdivisions but Federal loan agencies and mortgage companies tend to require elimination of overhead utilities. The telephone utility tends to bury its lines wherever possible. The city has an unwritten policy that no overhead utilities will be permitted in the central business area and electrical load requirements may preclude overheading in these heavily built up areas.

In Phoenix and Tempe, Ariz., undergrounding is required in all new subdivisions. In Phoenix, all high tension power lines 69 KV and over are overhead in major streets. In Tempe, any power line 12 KV or over may be installed on poles. In the older parts of town, power and telephone utilities use overhead lines in the alleys.

An undergrounding program has been completed in Greensboro's central business district but aerial plant is common in other parts of the city. Subdivisions built during the past five years have been served by underground utilities.

Kalamazoo's electric and telephone utilities, street lighting cable, cable TV and traffic signal lines are generally located overhead in the older sections of the city and underground in newer subdivisions. Overheading is common in the central business district, except in certain major streets and the city mall area.

In Ottawa, Ont., the core city utilities are almost all underground; some overheading is found in residential districts. The Oakland, Calif., utilities are underground in the central district, along major arterials and in new subdivisions. Overheading is common in older residential areas. Fremont, Calif., utilities are located in overhead locations in the older areas, but underground since 1967 elsewhere, except in the industrial sections of the city. The Portland, Ore., utilities are overhead in older sections but underground in the core city and in new subdivisions.

These examples of undergrounding versus overheading in typical metro areas are sufficient to lead to the general conclusion that (1) efforts are being made to place utilities underground in central business districts, and (2) that new subdivisions are being developed without overhead wires. The preponderance of overhead utilities in many older areas may explain why these communities have not yet felt the impact of underground crowding. They should be aware of the problems that may lie ahead and prepare for them by establishing location standards by which right-of-way space can be fairly and equitably allocated.

Absence of hard-and-firm utility location standards in most urban areas, in the years prior to today's new and awakened concern over right-of-way space, offered private utilities considerable flexibility on where they might install their plant. Of course, this freedom of choice was subject to the first-priority use of the underground by publicly-owned utilities; the privately-owned utilities took what was left. Judging from the foregoing discussion of undergrounding versus overheading, it is evident that the privately-owned utilities' choice, all things being equal, was for the cheaper overhead route. In Boston, for example, it is estimated that undergrounding would cost upwards of a half-billion dollars in the metro area.

Where undergrounding is practiced, either voluntarily or by mandate, rigid location stipulations are in effect in some communities, such as Baltimore County, while the first-come, first-served principle of space choice is used in other cities. A general summation of in-the-field findings on preferred locations for municipally- and privately-owned utilities shows that a large percentage would choose off-pavement installation points within the official right-of-way because of the cost differentials involved. Utility locations in the grassed medians, where they are available in street layouts, or in the unpaved area between the curb and the property line, cost less for both municipally- and privately-owned plant. Locations in unpaved areas may cost from 33 to 40 percent less for excavations and any necessary backfill-paving procedures. Electrical services in Montreal, for example, cost $14.25 per lineal foot in pavement areas, plus $4.50 per foot for paving, as opposed to $11.20 per linear foot in unpaved locations (1972 prices).

Where dual lines are laid on both sides of the same street, locations in the curb-to-property-line area can reduce the cost of house service connections and eliminate some of the hazards of utility relocation if street widening or other carriageway changes are made. Table 15, Preference for Location, summarizes a portion of the in-the-field investigation findings and shows the preference for locations outside of the pavement street width.

The Baltimore ducting system prefers under-the-sidewalk locations because of cheaper construction costs. Telephone interests would prefer under-sidewalk or alongside-sidewalk locations. The gas utility also prefers similar locations.

In Boston, water officials prefer a location under the pavement, 13 feet from the property line or six feet from the curb, five feet deep or more. Sewers are preferably located along the centerline of the pavement. Gas prefers a location of 13 feet from the property line, or six feet from the curb, opposite the location of the water lines. Telephone ducts are preferred under the sidewalk area or in a center mall. Electric facilities are preferred under the pavement, two to three feet from the curb. In Brookline, the present locations of city utilities are the result of free choice, because they have been given first priority; they are located under the pavement.

TABLE 15
PREFERENCE FOR LOCATION

Utility	Preferred Pavement	Preferred Median or Curb to Property Line
	(preferences)	(preferences)
Sanitary sewers	4	3
Storm sewers	1	2
Water	5	5
Gas	2	4
Electric	2	7
Telephone	1	8
Street lighting	–	3
Joint-use ducts	–	2

Source: 1973 Field Study by APWA

In Columbus, Ohio, where considerable undergrounding is practiced in a relatively high overheading community, telephone would prefer locations in the sidewalk or grassed areas; electrical interests so strongly adhere to the overheading principle that no underground location preference could be perceived. Gas prefers under-the-pavement locations despite the costs and pavement cut hazards involved. Sanitary sewer and storm sewer officials express interest in back-lot locations in private easement strips; for street locations, sanitary lines would be located under the pavement close to the centerline and storm sewers would use space close to curb lines. Water officials object to back-lot easement locations; 98 percent of water lines are located under the pavement.

In Des Moines, given their preferences, most utilities would be vying for the same underground location – not under the pavement; not in the sidewalk area; but in the grass plot, closest to the property line. This preference could be met by installing these utilities in a common duct or trench in the same vertical plane at varying depths.

Atlanta utilities have accepted undergrounding of new facilities as a way of life, induced by environmentalists, technical publications and aesthetes, but changeover to undergrounding of existing facilities is uneconomical except on a replacement and street betterment basis. The preferred utility locations are reported to be:

Sewers – center of roadway

Drains – under sidewalks

Electric – outer five to 10 feet of right-of-way

Telephone – back of curb in urban areas; outside edge of roadway in rural areas

Gas – shoulder of the road, or in sidewalk area

The Austin, Texas, telephone utility prefers underground to overhead locations, claiming a saving in cost for the former (a typical 1,500-foot buried cable costs $440 less than a comparable overhead line). The electrical utility prefers overhead construction because of cost benefits ($1 per lineal foot for buried lines and 50 to 60 cents per foot for overhead. This counter-preference of the two major privately-owned utilities illustrates the variable and unpredictable factors involved in location preferences.

In San Diego, the electric utilities have a strong preference for overheading to save money. The claim is made that electrical undergrounding costs from two to two-and-a-half times the cost of overhead lines. If underground locations are necessary, electric prefers a location at the back side of the sidewalk. When heavy feeders are used, a roadway location is preferred. In a conversion area, a back-of-the-sidewalk site is desired, with a parking lane position in the pavement as the next choice.

In Wichita, the telephone utility prefers a location between the sidewalk and the curb. In subdivisions, it would choose rear-lot locations in a dedicated public utility easement.

In Kalamazoo, the preferred utility locations are as follows:

Sanitary sewers – under pavement, just inside the curb

Water – in tree space or under sidewalk

Gas, electric, telephone – just outside the public right-of-way, in a private 10-foot joint-use easement

In Denver, Colo., still other preferences are expressed by publicly-owned and privately-owned utilites, as follows:

Gas – front yard easement, dual lines

Water – parking strip, dual lines

Electric – backyard or alley easements

Telephone – backyard or alley easements

Sewers – under pavement

In Oakland, Calif., the preferences are:

Telephone – under sidewalks, within three feet from the curb for main conduits

Electric – under sidewalk

Water – on north or east sides, offset from the street centerline

These examples are sufficient to demonstrate the variations in preferences from city to city. Yet, they disclose that under-the-pavement locations are open to great question and that a general preference for sidewalk or grassed areas is being evidenced. While it will be impossible to meet the confusing preferences of utility locations in all cases, a valid argument may have been made for the location of privately-owned utilities in common ducts or burial trenches outside of the pavement areas, reserving carriageway space for those utilities that can best utilize this space – water, sewers, storm sewers, and gas, except in cases where they, too, can be installed outside of paved right-of-way areas.

The water utility in particular, and other utilities in general, when considering placement of their plant beyond the paved area, must consider such problems as:

1. Potential destruction of private property due to absence of the containing waterway provided by curbs and gutters in the event of a water main break.

2. Probability of damage to private property during installation, and during possible subsequent connections as land uses change.

3. Difficulty of satisfactory restoration of surface improvements. These include trees, shrubs, lawns, sidewalks, driveways – all privately owned.

4. No fixed costs for restoration of surface improvement. Cost may vary widely.

5. Difficulty of installing back-taps to

mains within the parkway area. A back-tap connects to the main on the opposite side from which the service is needed.

6. Lower hydraulic efficiency of back-tapped connections.

7. Possible lack of space for vaults for regulators, meters and other waterworks appurtenances which are difficult to install due to their considerable size and weight.

8. Possible necessity of securing easements from the property owner to contain metering equipment if other utilities reduce available parkway space.

9. Objections by adjacent property owners for entry into parkway area that they are obligated to maintain.

10. Involvement with pedestrian safety during construction, operation and maintenance across sidewalks.

11. Financial loss to merchants with access blocked by behind-the-curb construction.

Failure of a water main with a pressure from 75 to 200 pounds per square inch creates a destructive force capable of great damage in a short time. A main break occurring within the curbed area of a street results only in pavement damage and some inconvenience to the traveling public. When a main break occurs in an area behind the curb, the impact is on the private sector of public and can affect trees, landscaping, architectural surface improvements and structures. In addition, water damage can and does occur to furnishings and materials within the modern "on grade" buildings being constructed today. Satisfactory settlement of damages is usually a problem since the owner may value his property or improvements differently than the utility would.

Space within the right-of-way is limited and thus the utilities which have legitimate reasons and rights to be located therein must protect its use. Any intrusions or encroachments add to the space allocation problem and affect the safety and economy of utility installations. These encroachments can result from installation of building vaults in the sidewalk areas which then conflict with preferred space for at least some utilities in some communities. Even those utilities which may join in mutual ducts or trenches, or participate in municipal duct systems express firm desires for separate and independent vaults, manholes or other connection or servicing chambers. These separate structures in the underground can usurp valuable space and impair the construction and maintenance operations of other utility services.

In the category of encroachment must be included the excessively large and lengthy underground ducts which utilities, such as telephone, often built in dense urban areas adjacent to their principal. These ducts result in the so-called "Chinese wall" problem discussed elsewhere in this Report. Boston officials expressed serious concern over this impenetrable type of structure and its effect on the ability of other utilities to cross them to provide connections or services on opposite sides of the street.

Utilities can, themselves, encroach on other structures. In Baltimore, Md., utilities located close to old buildings built on rubble footings have threatened these foundations by digging operations. The solution involves limitation on the closeness cf such utility structures to building lines, resulting in a reduction of the underground space available for utility locations in such cases.

In Columbus, Ohio, encroachment problems include consideration of the intrusions on privately-owned utilities by city street relocation projects. This problem has impact in all governmental utility work which may encroach on the space separations desired by other utilities to protect them against structural damage, and produce corrosion conditions, induce conductance effects and interfere with servicing and future enlargement plans for the affected utility works. The general municipal policy is that privately-owned utilities are required to protect themselves against any work performed by ministerial government. However, some municipalities have at least considered the principle of part-sharing of utility relocations made necessary by public projects. Montreal has shared such costs under certain conditions. In the construction of the Montreal Metro system, the relocation of all affected existing utilities were paid for.

Few metropolitan communities reported such problems, possibly because data are missing and the effect of encroachments has not been studied as part of the right-of-way problem. Portland, Maine, reported that building footings and sidewalk vaults in the central business district have encroached on useable right-of-way space. Similar conditions were noted in Seattle. Location of electric service vaults presented a major planning problem for the rerouting of utilities in Chicago in conjunction with new subway construction.

When streets or alleys are vacated by municipal development plans, the preponderance of the surveyed municipalities reported that the utilities absorb the cost of relocating their facilities to other points. These relocations are required when the vacated right-of-way is to be used for construction of structures or other urban projects which could be affected later by utilities which fail and may require excavation. Other municipalities may require the new owner to either provide access for the utilities or else to pay for their relocation.

Constraints exist in locating utility plant due to the proximity of other utilities. Safety and physical features of the nature of service require adequate separation of plant.

Safety requirements are necessary to ensure adequate space for maintenance operations and protection of adjacent plant. Physical features include interference between electrical and communications, heat loss for electrical, and separation of water from sewers to prevent contamination.

Typical of separation requirements are those of the Bell System given in Table 16, Separation Standards.

TABLE 16
SEPARATION STANDARDS
BELL SYSTEM

I. AERIAL

Minimum Vertical Clearance From Ground

Public highway	18 ft
Public alleys	15 ft
Driveways	15 ft
Walkways	8 ft

Minimum Vertical Clearance for Telco Plant Crossing Foreign Plant

Line wires–0-750V	4 ft
750-8700V	4 ft
8700-50,000V	6 ft
50,000V over	Relocate

Service supply–0-750V 2 ft or 4 ft if Telco is above server

Foreign communications plant – 2 ft

Joint Use Vertical Separations

0-8700V (at pole)	40 in.
8700-50,000V (at pole)	60 in.
0-8700V (in span)	30 in.
8700-50,000V (in span)	45 in.
Between Telco cable and street light bracket	12 in.

II. BURIED

Telco Cable Crossing

A. Power cables in ducts or buried – 12 inches of well-tamped earth or 3 inches of concrete

B. Gas, water, or oil pipes, etc. – 6 inches of well-tamped earth or 3 inches of concrete

Telco Cable in Same Trench

A. 0-7600V with parallel exposure ≤ 1/2 mile – random lay may be used

B. Power cable in ducts – 12 inches of well-tamped earth or 3 inches of concrete

III. CONDUIT

From Telco Conduit

A. Electric light, power, etc. – at least 3 inches of concrete, 4 inches of brick masonry, or 12 inches of earth.

b. Other foreign pipes such as gas, oil, water, etc. – at least 6 inches clearance when crossing and 12 inches when paralleling

State health departments have set varying requirements for separation of water and sewer systems.

EVALUATION

A sampling of the highlights reported by the field investigators sheds some additional light on the state of the art of the utility location problem.

Columbus, Ohio, offers an example of regulating practice where utility locations in new subdivisions are partially formalized by regulations and standards and partly based on each-case-for-itself concepts, depending on local conditions. The effectiveness of utility locations in these development areas is dependent on actions by the city council, as often recommended by planning and zoning and the public service department. Crowding of utilities in densely developed areas can be resolved only by major relocation policy changes and rigid enforcement.

In Des Moines, Iowa, subdivision regulations covering utility locations are adequate but enforcement decisions are based on mutual-consent opinions of the members of the Utilities Coordinating Committee.

Atlanta is another example of where regulations covering new development utility locations are adequate but they are not always backed up by actual enforcement of their provisions. The utility crowding problem in the central area of Atlanta, while not presently desirable, is considered "palatable" under current state-of-the-art conditions. The city is almost fully developed and is land-locked by surrounding municipal entities. Only as utility plant is replaced can new methods and procedures be considered.

To resolve utility location toubles, Austin, Texas, is considering the construction of a utility tunnel for the Congress Street improvement area. This is an application of the principle of utility location betterment by the checkerboard formula of correcting existing defects whenever an area is rehabilitated.

Phoenix, Ariz., has made experimental attempts to allow construction of utilities in standard locations without submission of any permit drawings. Results are inconclusive due to inadequate uniformity of location standards and lack of experience in the application of this voluntary program. New location standards are currently being invoked in new subdivision areas, and in street widening projects where this is feasible.

San Diego has launched a program of permitting its major utilities to develop their own working rules and regulations, through an annual review of the Administrative Practices Manual.

Kalamazoo officials agree that joint trenching, conduits, cableways, ducts or utility tunnels, coupled with advance planning, can resolve future utility crowding conditions. A committee has been formed to review development plans, in the presence of utility representatives, to insure adequate space for utility accommodation. Minneapolis believes that the best solution for utility crowding would be use of common trenches and utiladors. Gas and steam lines, however, will pose a problem if common conduits are required. Ottawa's opinion is in agreement but it fears that problems of utility depths, and other non-amenable factors will prevent common conduitways from solving all space allocation conditions. Winnipeg believes that common trenching or other techniques will resolve many problems and that individual utility objections must not cause such mutual location arrangements to be avoided.

An overall evaluation of utility state-of-the-art location and installation conditions was received from each investigator, covering all of the metro communities each had surveyed in week-long residence. One such summary review is included here for the purpose of showing the general trends and developments in representative central cities and suburban satellite communities. It covers not only the problems of utility franchising, locations and standards discussed in this chapter, but related regulatory practices, construction methods, manpower conditions, utility dependability and other facets of the total utility accommodation problem in urban rights-of-way covered by other chapters in this Report.

EXCERPTS FROM A SUMMARY-COMPARISON OF PRACTICES

(Covering observed conditions in five Metropolitan Areas)

Despite the wide variation in the goegraphical areas represented by the five metropolitan areas which were surveyed by the investigators and the diversity of their population sizes, their demographic-economic characteristics, the urban format of the cities, their ages and status of pre-planning of utility services, and community traffic patterns, certain common denominators were found in their ROW/utility accommodation policies, practices and performances.

A. – Community Profiles

1. In all areas, the central city provides water services to the suburban community and renders interceptor sewer and sewage treatment services for predetermined charges to the satellite government unit or its residents.

2. The privately-owned utilities which serve the central city provide similar services to the suburb, follow the same general construction and maintenance procedures and seek the same type of cooperation and participation in its problems by local governmental entities.

3. Absence of utility coordinating committees affects unification of ROW/utility location policies and practices, but voluntary cooperation between privately-owned utilities and government regulating agencies helps to bridge gaps which develop as a result of lack of a formalized group.

B. – Existing State-of-the-Art

1. Central city areas were developed without clear-cut planning or determination of utility locations in the ROWs. As a result, the general rule is that accommodation space is now limited and will become more critical unless major relocations and redevelopments can be accomplished.

2. In general, standards for utility locations were not imposed as CBD areas developed. Even without standards some semblance of orderliness in ROW/utility accommodation has been achieved through voluntary cooperation.

3. Cities allow privately-owned utilities space in ROW areas without cost, but they reserve the right to dictate, by engineering review and issuance of construction permits, where the utility facilities will be located.

4. In all cases, publicly-owned utilities reserve first priority in ROW locations, and privately-owned utilities are required to accommodate their facilities in the remaining space. In some cities, efforts are made by regulating agencies to meet privately-owned utility needs and preferences when this is possible without impairing the prior rights of such services as water, sewers and storm drains.

5. Wherever heavy ducting construction occurs in the congested older areas of metropolitan cities, telephone utilities build the largest and deepest underground structures. The threat of impenetrability of these duct banks is of immediate concern in some cities and a future problem in others.

6. In suburban communities, ROW/utility accommodation problems in CBD areas are not as pressing because they were developed later than those in the central cities. Not all benefitted from lessons learned in the uncontrolled and unstandardized growth of the older core cities. Publicly-owned utilities are given first priority in the ROW in satellite communities but accommodation of privately-owned facilities is not as severely affected in suburban areas.

7. In both central cities and suburban communities, the agency which maintains control over utility locations either by edict or by veto power over requested construction applications is usually the department of public works, through its engineering division, with supplemental regulatory control by traffic, planning, zoning and urban renewal agencies.

C. – ROW/Utility Practices in New Developments and Relocations

1. Most agencies have learned from past inadequacies in control and regulation of ROW space allocations and have applied this knowledge in planning for new subdivision developments and in urban relocation and rehabilitation work. To this end, the majority of urban centers have established standards for ROW widths and for the location of publicly-owned and privately-owned utilities over, under and in property-line-to-property line areas.

2. The trend is toward the undergrounding of utilities in subdivision developments, either by adoption of city standards, or if not by edict then by persuasion, backed up by the desire of developers or property owners to improve the appearance of new areas.

3. Undergrounding standards imposed by city or state legislation are frequently not strictly enforced in subdivision or urban relocation areas because of the high cost of facility conversion within private properties or pressures by privately-owned utilities which object to unshared costs of utility conversion.

4. Privately-owned utilities, particularly electric companies, want someone to share the differential costs of undergrounding – either developers or city agencies.

5. Most municipalities have established ROW widths and standards for water, sewers and storm drains for subdivisions; in general, ROW minima are greater than for comparable roadway purposes in existing areas. Adherence to these criteria is designed to assure adequate space for the required utilities.

6. Generally, the developer is required to build roads, sewers and storm drains, and to provide water distribution mains, or to reimburse the city for the cost of installing these facilities. All cities, both central communities and suburb communities, require construction to meet established standards. Bonding of developers to assure proper construction and performance is common practice.

7. Dedication of roads and public utilities to public ownership is a firm requirement before formal acceptance of the subdivision as an integral part of the municipality. In a minor number of cases, developers may choose to retain the privacy of their subdivisions and to contract for city services if the cities are willing to accept this practice.

8. Acceptance of subdivisions is not the function of the agency authorized to regulate ROW/utility accommodation policies. This power is vested in the local legislative body, the city council or board, usually based on technical certifications by public works, engineering, planning or zoning agencies.

9. The developer is required to grant adequate ROW easement space for utility installations and, often, to provide back lot or side lot additional easements without cost before acceptance procedures are initiated. Governmental agencies then grant easements for private utilities without cost but they must negotiate with property owners for other easement rights not owned by the city.

10. Normally, little or no fee is paid by cities for extra easement strips but in some instances payments are made for such rights at going land values if the cost of going through private property would be less than avoiding such routes. Not all cities claim right of eminent domain, or else choose not to invoke it.

11. The location of utilities in subdivision areas is normally specified and strictly enforced. The trend is to locate publicly-owned and privately-owned utilities out from under the pavement wherever this is feasible, with the greater emphasis on this location for all facilities other than water and sewer lines.

12. Sewer and water house connections are installed by cities, or in conformity with their standards. the actual placing of lateral lines may be carried out by property owners through licensed plumbers or drainlayers. Privately-owned utility house connections are made by the utilities at a predetermined cost to the property owners who pay in full or share the differential cost of undergrounding of such services. This differential cost may be higher for electric than for telephone services. Installation by direct burial is common practice.

D. – Occupation Rights

1. Privately-owned utilities occupy space in ROWs in most cases not by sufferance but by specific state franchises to utilize public ways for public service, or by local ordinances of some nature. Some franchises are open-ended; others are for stipulated time periods, subject to renewal or renegotiations.

2. In spite of such franchise rights, cities generally retain control over where, how and when, and for what purposes, utilities may occupy ROW space. The power is used by review of construction and reconstruction proposals and the issuance of permits to place facilities on, over and under ROWs. State franchise legislation and local ordinances define the power of cities to control their own public ways.

E. – Permits and Control of ROW Operations

1. The basic permitting agency in practically all municipalities is the department of public works, with the engineering unit serving as the departmental agent.

2. Some facets of licensing or permitting are handled by ancillary agencies such as traffic and transit, buildings or other units of local government.

3. Where major projects are involved, such as subdivision developments and urban relocation or redevelopment, the final authority is vested in the local legislative body, but this authority is invoked only after technical certification of project details has been made by the city's basic permitting agency or agencies.

4. Permits are often issued on the basis of application forms submitted by privately-owned utilities by letter, with necessary plans and other details appended thereto. Permits may be inscribed on the application letter but, more often, are issued on city forms in multiple copies for distribution to the permittee, city foremen or inspectors, police and office files.

5. Where applications for permits cover new installations or relocation of underground utilities, the permitting agency distributes copies to affected city agencies and requires their approval before authorization is issued. The time required to clear applications varies with the number of agencies involved in the routing program. In general, smaller suburban communities vest permitting authority in one agency, normally public works or engineering, and only one man is involved in review of applications. Such "one-man operations" can provide rapid approval of applications.

6. There is no universal policy on charges for permits; some cities impose fees, others do not, particularly for private utilities. In general, privately-owned utilities are not required to post bonds for each job but blanket bonding of such utilities is practiced by some cities. Private contractors, working for these utilities, are usually subject to the same rules applied to those who retain them. Plumbers and drainlayers are frequently required to post bonds to assure proper performance of their work and are charged for permits.

7. Publicly-owned utilities – water, sewers, storm drains, street lighting, traffic controls, and police and fire communications – are not universally required to obtain permits for ROW work. This gap in the permitting system may affect the completeness of ROW records but the permitting agency is usually apprised of such work because of the close relationships between it and these public utility functions.

8. Privately-owned utilities carry out a continuing program of communications with their fellow utilities to assure themselves that interferences and damage will not occur during underground operations.

9. Permit forms, when issued, normally carry routine rules and regulations on ROW activities, either on the face of the permits or the reverse side of forms, outlining special stipulations, time of work and other matters relating to the performance of work and protection of traffic patterns. The city is generally held harmless for any damages resulting from the permitted work.

10. There is a general absence of any unified master mapping of all utilities located in ROWs.

11. Some form of permit filing system is used by all cities but this universality does not apply to the method of filing and preserving these records. The use of microfilm records is becoming more common.

12. The licensing or certification of plumbers and drainlayers is common practice, either by state or city action. Local control of their operations is usually vested in a building department rather than a public works or engineering agency.

F. – Inspection and Control of ROW Work

1. Inspection of ROW cuts and excavations, and of utility work therein, is one of the weak parts of local utility accommodation programs. Most cities complain about shortages of inspection personnel and inabilities to keep abreast of the work load. Inspections, when made by city staffs, are handled by public works personnel assigned to the engineering division.

2. There is a tendency to depend on the permittee to inspect his own work and to guarantee the effectiveness of replacement work on excavations and surface restoration, with city inspectors performing post-construction checkups. This procedure is dependent on faith rather than fact.

3. When performed by city personnel, inspection costs are not uniformly assessed by all municipalities. Where so assessed, the charge is based on some hourly rate, a

percentage of the inspector's salary, or some other criterion.

4. Traffic warning signals, barricading equipment and maintenance of traffic in at least one lane of obstructed streets are normally enforced by traffic engineering and police traffic officers. Most cities have adopted formal rules for ROW traffic control and protection procedures, in the form of booklets or brochures. Accidents due to ROW incidents are investigated, as routine procedure, by police and reported to traffic engineering for evaluation.

G. – Trenching and Surface Restoration

1. Most cities have established standards for backfilling and resurfacing of ROW cuts and excavations, some based on state highway specifications and others on their own specifications. The type of backfill material varies among the cities but compaction by tamping, without water and in thin layers, is a common requirement.

2. Permittees are required to backfill excavations. The majority of cities requires utilities to place temporary surface material on cuts, which is later removed and replaced with a permanent surface course, by or under the direction of the city. In some cases, the permittees, particularly privately-owned utilities, are charged with the responsibility of making the permanent replacement themselves.

3. Cities usually ban pavement cuts in newly laid roadways for periods ranging from one to five years. In some cases, any cuts made within the ban period are assessed penalty fees. The rigidity of these regulations in the case of emergency cuts is subject to variable interpretation because such ROW work cannot be delayed without endangering life and property.

4. The consensus is that pavement cuts affect the ultimate life of roadways, regardless of how effectively backfill and resurfacing operations are carried out. The better the work, the less the detrimental effect. Most cities require cut restorations to be larger than the original cut dimensions and some stipulate that the entire width of the street or the lane be repaved to prevent damage to the pavement. Bore hole or bar holes made by gas utilities searching for leaks, if not plugged, can cause water and ice deterioration of base courses and the pavement itself.

H. – Designing for Future Needs

1. The general policy is that cities hold privately-owned utilities responsible for the cost of relocating their facilities, overhead and underground, even if these changes are made necessary by city ROW modifications. Variations from this policy are so infrequent that any sharing of such costs, in whole or in part, by city government can be characterized as abnormal and based on local conditions which are not universally found in other communities.

2. Urban redevelopment projects offer some cities the opportunity to correct ROW/utility accommodation practices made in central areas and CBDs when they were originally developed. An upsurge in urban renaissance is now underway in an effort to revive central city life and business and recreational activity; these face-lifting operations, whether carried out under the auspices of Federal-city financing or private initiative, provide a challenge to relocate utilities and to convert from unsightly overheading to undergrounding by official edicts or voluntary mutual agreements. If the rigidity of cost-charging against privately-owned utilities is ameliorated in such instances this could provide opportunities for marked improvements in older areas.

3. Standard procedures are not in effect on how costs are allocated for oversizing or overloading of utilities to meet future needs. In general, cities tend to absorb the cost of excess sizing of water, sewer and storm drain utilities, either on a capital cost basis or as a general budget charge. The fiscal ability of city agencies to pay for such future needs often acts as a deterrent to "burying future assets" with current funds. Privately-owned utilities tend to absorb the costs of such excess sizes and capacities, on the basis that original costs will be less than future expenses of installing additional facilities. These utilities would expect to recoup their costs through rate structure increases authorized by state public utility agencies. The ability of private utilities to carry out such work-for-the-future programs is limited by the

flexibility of their budgets.

4. The cost of utility relocations varies widely, but costs in densely developed areas can exceed costs in open areas by twice or more; electrical differential is generally higher than those experienced by telephone utilities.

I. – Utility Location Preferences

1. Privately-owned utilities prefer overhead construction due to the cost differentials involved in underground locations, except where these costs are met or partially met by developers or city government.

2. The installation of heavy banks of ducts, particularly for telephone services, adjacent to switching facilities in the CBD now poses or threatens to pose problems but these banks do concentrate utilities in one location rather than having them scattered throughout the ROW space. Anything which tends to cluster utilities in one central structure may be helpful in preventing or correcting crowded conditions.

3. Municipally-owned ducting systems, available for multi-utility use, as opposed to the single-utility concept of telephone ducting banks, represent a potential step toward utility tunnels. Such joint ducting is practiced in Baltimore, Montreal and Verdun, Quebec. These systems must provide for separate and independent manholes and vaults for each utility to overcome their objections to joint systems and to prevent the hazards and interferences that would result from dual-utility chambers.

4. The trend in private utility locations is toward under-the-sidewalk areas, or between the sidewalk and property lines. Most utilities want to be in the same place; joint trench locations are the only feasible answer to this unsolvable preference.

5. Multiple use of poles is common practice; common trenching is less universally acceptable but no insurmountable objections are raised by private utilities where adequate space is available and hazards of interferences, heating and other adverse phenomena can be eliminated. The joint trenching of water and sewer lines is viewed by some cities as a potential sanitary hazard but it is used under certain circumstances, particularly in rock trenches, where adequate separation of the two lines can be achieved or where water mains can be benched at a higher level than deeper sewer lines.

J. – Utility Construction Methods and Standards

1. Despite the fact that each city adopts its own construction and materials specifications, some patterned after state standards, general likenesses exist from city to city, due without doubt to the existence of national standards established by such organizations as the American Society of Civil Engineers, American Public Works Association, American Water Works Association, the Water Pollution Control Federation, American Society for Testing and Materials, American Standards Association and others. Local variations are to be expected to meet specific conditions in each community. The standards of central cities are usually adopted by suburban communities.

2. Privately-owned utilities have their own standards on materials and workmanship, derived from their own experiences in their service regions, or stemming from criteria developed by national technical organizations in their own utility fields, such as Edison Electric Institute, Bell Telephone Laboratories, American Gas Association and other organizations.

3. Privately-owned utilities vary in their use of company crews or contractors to carry out major construction, relocations and service repair operations. The tendency is for these specialized utilities to use their own trained crews for wire and piping work and to retain contractors for earth-moving purposes.

4. Examples of "Call before You Dig" programs on a unified utility basis are scattered throughout the country but the more common procedure is for each utility to operate its own call-dig plan. In such cases each utility promotes its own call number, issues its own warning and alert signs and literature, and handles other parts of its plea to others to "look before you leap." Even without a unified call program the utilities in any area maintain close communications with each other. The problem is not from the inside; it is the outsider who creates the hazard of promiscuous dig-ups.

Privately-owned utilities are aware of the advantages of a unified program and an increase in inter-utility systems can be expected in the near future.

K. – Utility Dependability and ROW Effects

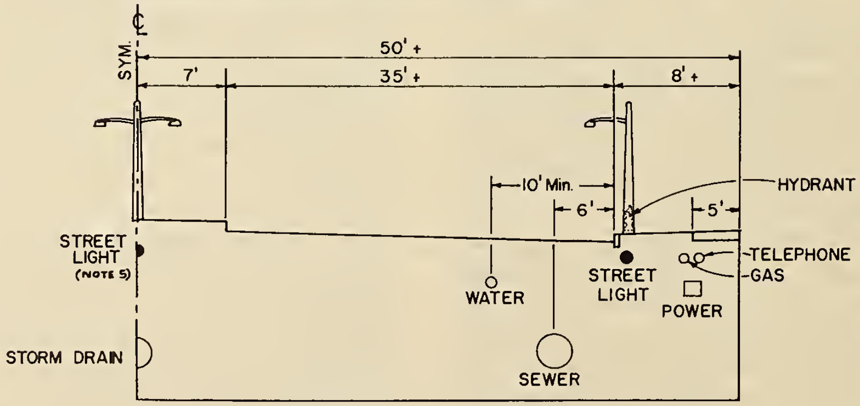
1. Underground utility facilities experience more or less frequent failures, due to various causes, some of which might be attributed to load, shock and other impacts on roads and streets and abutting properties. The most frequent cause of pavement cuts is for gas services, covering planned improvements and emergency incidents. In many cases, these gas cuts represent as much as 90 percent of all cuts made by privately-owned utilities.

2. Water failures are more frequent than sewer incidents. Many of the service failures in the latter utility can be corrected by work within the manholes of the system. A minimum of ROW cuts are caused by work in connection with other municipally-owned utilities such as street lighting, traffic signals and various communication systems.

3. So-called street openings, as defined by the opening of manholes and/or vaults for servicing purposes, create ROW traffic interferences, as do jobs carried out on overhead facilities which require the parking of equipment and the use of overhead

The prime consideration for locating power, telephone and gas in a common trench outside of the traveled way is to allow the greatest access for maintenance with a minimum of conflict with vehicular traffic. The local sewer is located in the normal parking area of the traveled way for easy access to manholes with maintenance equipment while minimizing conflict between the equipment and normal traffic. The minimum four-foot spacing between the sanitary sewer and the water main provides adequate room for the construction of manholes. If dual lamp fixtures are used, the light standard may be located in a raised median rather than immediately behind the curb.

1. Storm drain location dependent on size and purpose.
2. Utilities shown are local distribution only. (Size of facility may require special consideration.)
3. Between curbs minimum cover measured to top of utility shall be 12 inches below subgrade but not less than 24 inches below roadway surface except that water mains shall be not less than 30 inches below roadway surface. Minimum cover in back of curb 18 inches.
4. Street trees midway between curb and street side of sidewalk.
5. Alternate location for street light if dual lamp fixtures used.

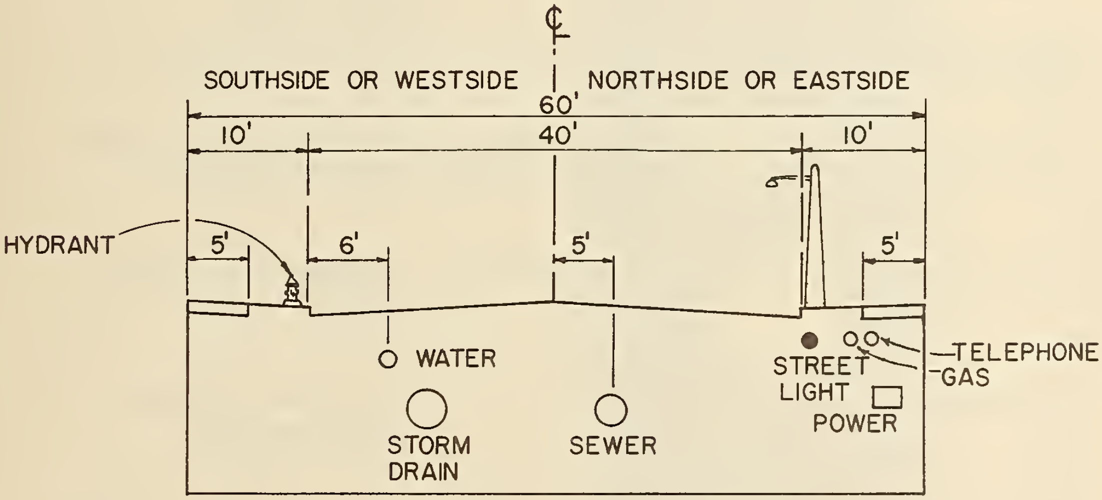


a. Major Street – 100′ Right-of-Way and Wider

FIGURE 10 TYPICAL UTILITY LOCATIONS, SOUTHERN CALIFORNIA APWA CHAPTER

Reasons for suggested location of utility facilities are the same as for those in the wider streets under Figure 10. The primary concern is to place facilities where they will cause the least inconvenience to the traveling public when exposed for maintenance, repair or additional service. Maintenance equipment may be parked adjacent to curbs, centerlines or on parkways without unduly obstructing through traffic.

1. Storm drain location dependent on size and purpose.
2. Between curbs minimum cover measured to top of utility shall be 12 inches below subgrade but not less than 24 inches below roadway surface except that water mains shall be not less than 30 inches below roadway surface. Minimum cover in back of curb 18 inches.
3. Street trees midway between curb and street edge of sidewalk.
4. Utilities shown are local distribution only. (Size of facility may require special consideration.)
5. Alternate sewer location on C/L street, offset recommended to preserve survey monuments.
6. Telephone, gas, power and water may be located on both sides of street.



b. Local Street – 60 foot Maximum Right-of-Way
Sidewalk adjacent to property line

FIGURE 10 TYPICAL UTILITY LOCATIONS – SOUTHERN CALIFORNIA APWA CHAPTER

servicing devices and vehicles. These incidents are not covered by the usual permitting system and frequently are not adequately brought to the attention of regulating agencies.

4. No specific and dependable cost factors per mile of utility, or other unit pricing can be deduced from the experiences reported by city and private utilities. Cost vary widely depending on the nature of the work, local conditions and other factors.

5. Accidents due to ROW incidents are reported in such generalized terms — “infrequent” and “seldom” — that no valid data can be deduced from urban experiences. Cities are frequently named as co-defendants in such claims for damages.

APWA Southern California Chapter Standards: These standards have been referred to earlier in this chapter. Suggested street layouts are shown in Figure 10, Typical Utility Locations, Southern California APWA Chapter.

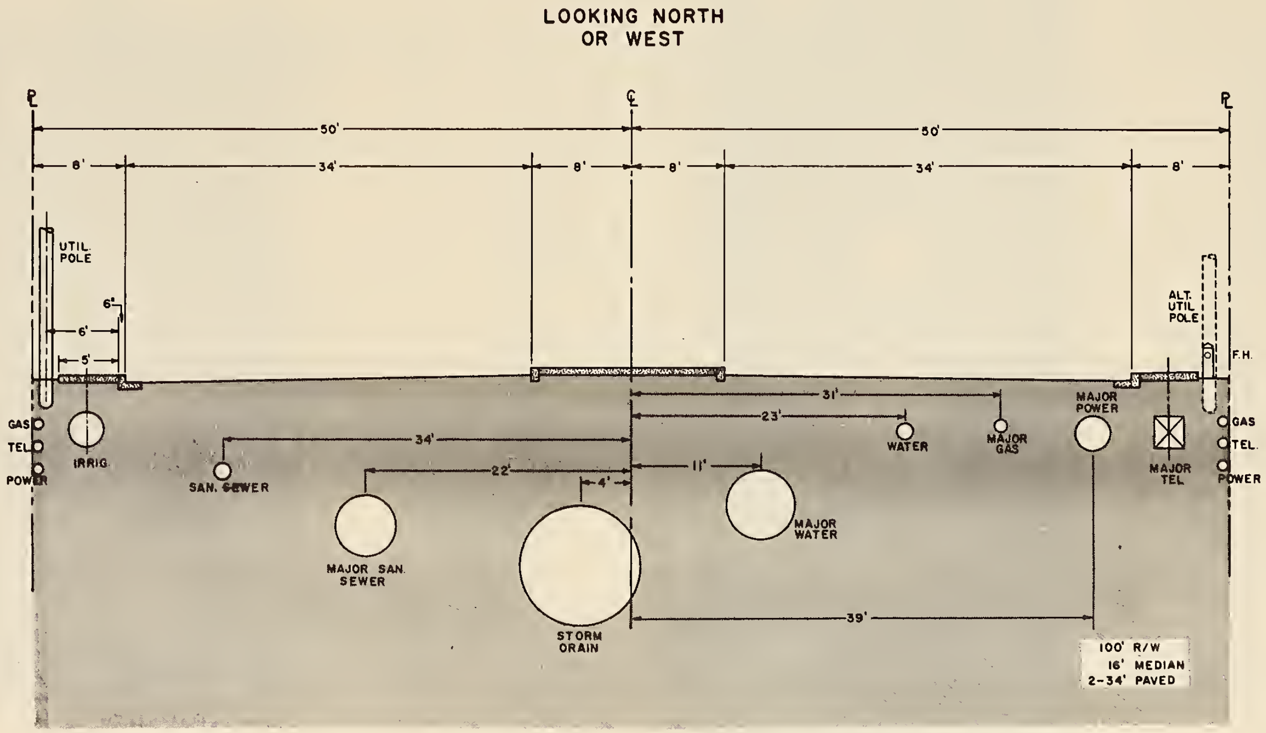
New York City Standards: Utilities in New York City are required to locate plant facilities in accordance with the criteria given in Table 17, New York City Standards.

Phoenix Standards (typical cases): Standard Utility Locations for the City of Phoenix, Ariz., were prepared in June, 1970, by the Standard Utility Location Committee. Figure 11, City of Phoenix Location Standards, contains excerpts from the total accommodation plans to illustrate the basic location concepts used in the Phoenix program.

TABLE 17

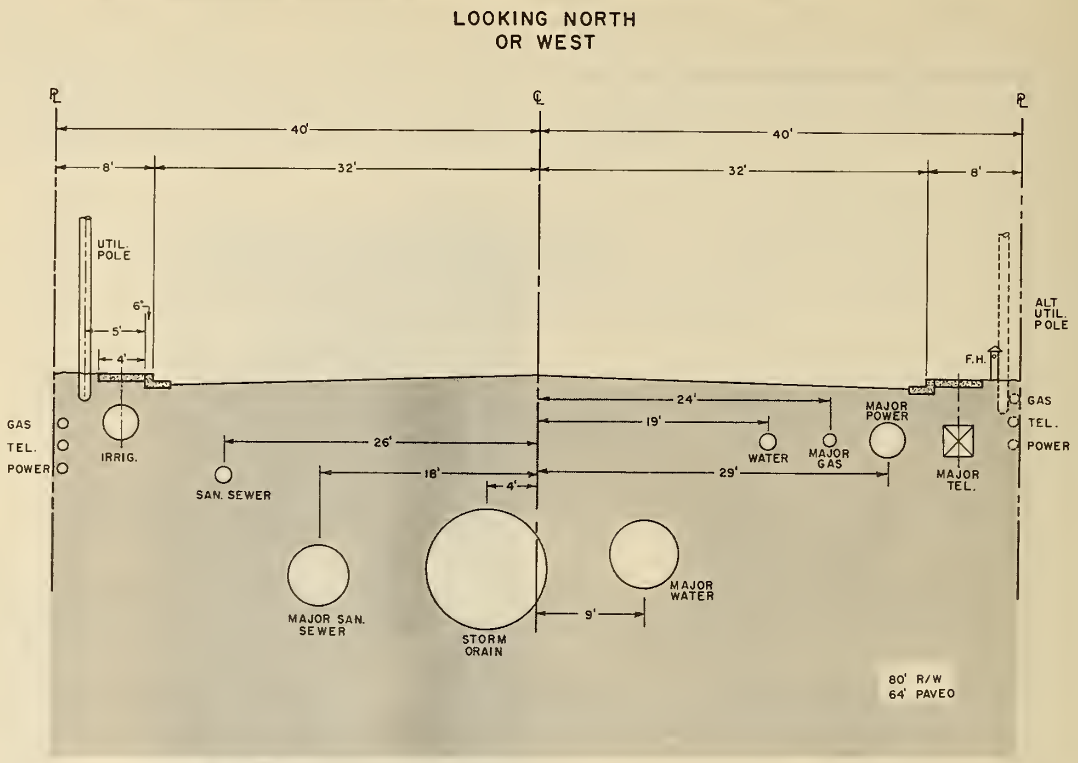
NEW YORK CITY STANDARDS

Utility	Location Below Finished Surface	Location Horizontally
Low Pressure Water Mains	4′ - 0″	] 1′ - 0″ to 1′ - 6″ from] nearest utility
High Pressure Water Mains	5′ - 0″	] 4′ off curb normally
Sanitary Sewers	Depth-Lowest House Connection	Centerline Street or both sides of Storm Sewer
Storm Sewers	3′ 0" Min.	Centerline Street where possible
Storm Basin Connections	Varies	As required for Storm Sewer connection
Electrical Distribution Ducts	1′ - 6″ to 1′ - 10″ desired	1′ clear of adjacent utilities
Electrical Transmission	] 3′ - 0″ in Street] 3′ - 6″ in Sidewalk	1′ - 0″ clear of utilities 12′ - 0″ clear of steam mains or 6 or more duct banks Clearances may be reduced if cooling system is incorporated in transmission system
Telephone Ducts	] 2′ - 0″ in street] 2′ - 6″ in sidewalk	Near curb where practical
Steam Mains	2′ - 6″	1′ clear of other utilities
Gas Mains	3′ - 0″	Parallel to other utilities

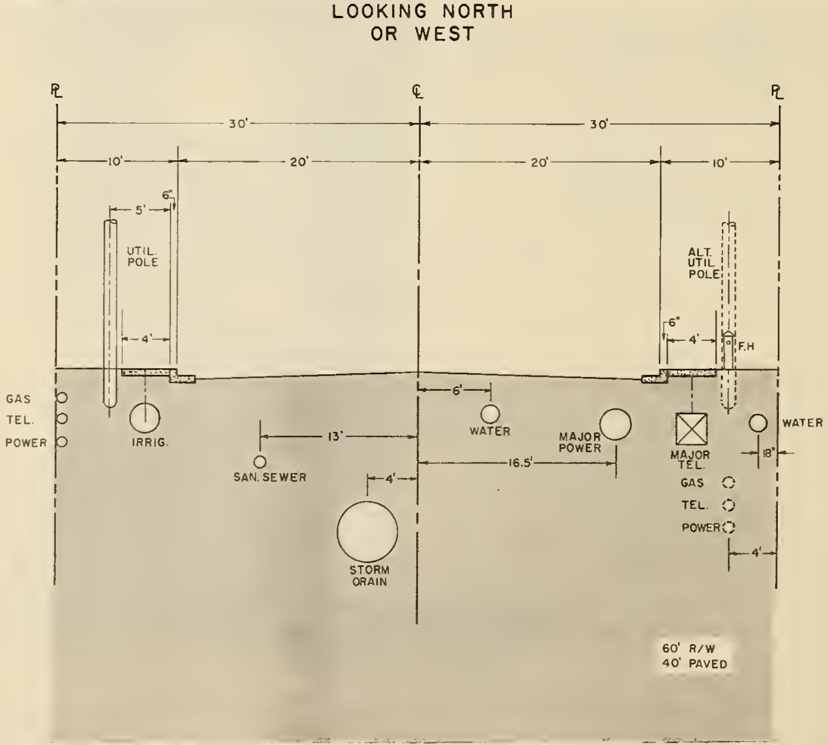


a. Major Street

FIGURE 11 LOCATION STANDARDS
CITY OF PHOENIX, ARIZONA



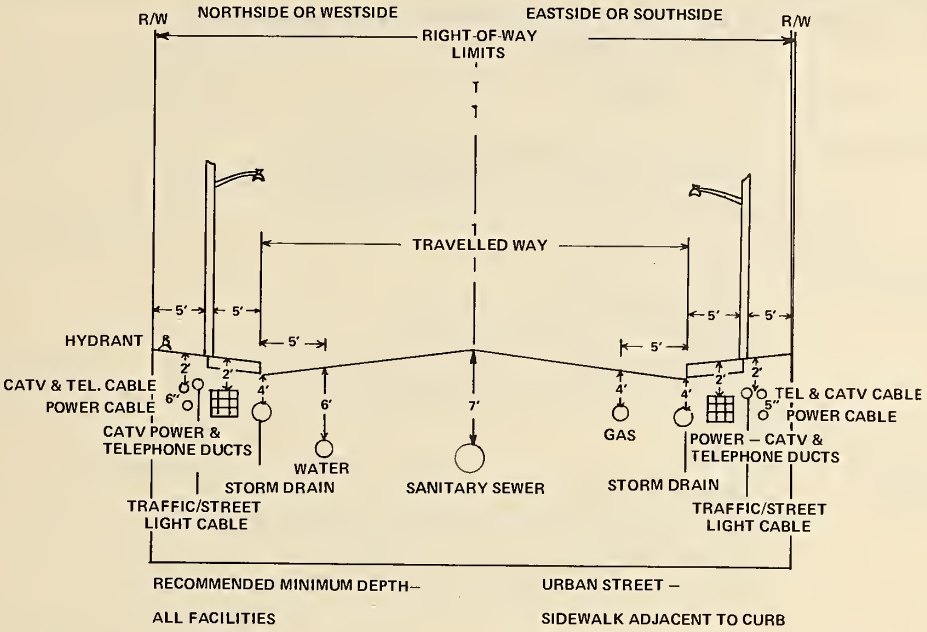
b. Collector Street



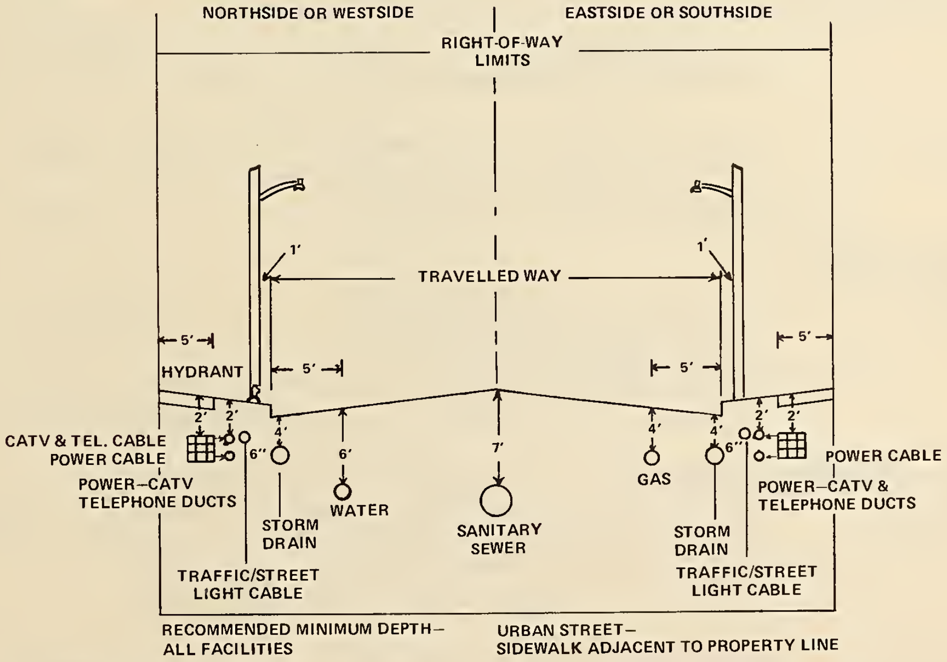
c. Collector Street, Residential Areas

FIGURE 11 LOCATION STANDARDS
CITY OF PHOENIX, ARIZONA

Maine State Liaison Committee – American Right-of-Way Association: Figure 12(a) and (b), Typical Utility Locations, Maine, were prepared by a subcommittee on highway utility space allocation in 1973. The representative sketches are supplemented by a listing of recommended location practices.



(a) representative sketch



(b) representative sketch

FIGURE 12 TYPICAL UTILITY LOCATIONS, MAINE

MAINE
RECOMMENDED HIGHWAY SPACE ALLOCATION
URBAN AREAS

ELECTRIC SYSTEMS:

Below Ground – Location under the sidewalk area (either side).
Operational width – 5 ft
Recommended minimum depth – 2-1/2 ft of cover

Above Ground – Poles and light standards – (either side).
Face of structure 1 ft in back of face of curb; or,
5 ft inside right-of-way line

GAS SYSTEMS:

Location – on south or east side of street.
Location 5 ft inside berm/curb
Operational width – 6 ft
Recommended minimum depth – 4 ft of cover

SEWER/STORM SYSTEMS:

Location – highway centerline for sanitary
Gutterlines for storm (at curb) – both sides.
Operational width – 6 ft
Recommended minimum depth – 7 ft for sanitary,
4 ft for storm

CATV/TELEPHONE SYSTEMS:

Below Ground – Location under sidewalk area (either side).
Operational width – 5 ft
Recommended minimum depth – 2 ft of cover

Above Ground – Poles and pedestals – (either side)
Face of structure 1 ft in back of face of curb; or
5 ft inside right-of-way line

WATER SYSTEMS:

Location – on north and west side of street.
Location 5 ft inside berm/curb
Operational width – 6 ft
Recommended minimum depth – 6 ft of cover
Hydrants – 1 ft in back of face of curb; or inside right-of-way line

TRAFFIC/STREET LIGHTING:

Location – adjacent and generally parallel to pole line – (field side . . . either side)
Recommended minimum depth – 2 ft

Seattle, Wash., Standards: Table 18, Utility Standards, Seattle, Washington, lists standards for utility locations which were developed for a typical 60-foot street with a 25-foot pavement and a five-foot sidewalk.

TABLE 18

UTILITY STANDARDS, SEATTLE, WASHINGTON

Walk – 5 feet wide		Pavement – 25 feet wide
	Distance from Centerline	Cover
*Electric Power	15 feet	Ducts are 3 feet between intersections, 4 feet at intersections, maximum 6 feet deep
*Gas	13 feet south & west	30 inches
Sanitary Sewer	at centerline	– – –
**Storm Drain	7 feet south & west	48 inches minimum
*Telephone – local direct burial	23 feet	16 inches
– trunk	same as power	same as power
*Television	22 feet or same as telephone	16 inches
*Trees	16 feet	– – –
Water	10 feet north & east	35 inches (per standard schedule)
*Water Meter	19 feet	– – –

Services: 20- to 30-inch depth from curb to property line reserved for lateral service.

Sanitary side sewer minimum cover is 30 inches at property line and 60 inches at the curb

Storm drain side sewer may run under the sidewalk thru the curb or thru above reserved space.

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* Electric power, gas, telephone, television and trees will be installed in the same relation to the curb on streets with pavements in excess of 25 feet.

** Storm drains will be permitted in the area under the planting strip or under the concrete walk where the roadway has permanent pavement. Other utilities may be placed above the storm drain.

Los Angeles-San Diego Proposal: Figure 13, Proposed Common Trench Utility Locations, Los Angeles, San Diego, is the utility layout in common trench construction which was proposed in a paper presented at the American Water Works Association's 92nd Annual Conference in Chicago, on June 7, 1972, by Gerard A. Wyss, Assistant Chief Engineer of Water Works, Los Angeles, and Roy E. Dodson, Water Utilities Director, City of San Diego.

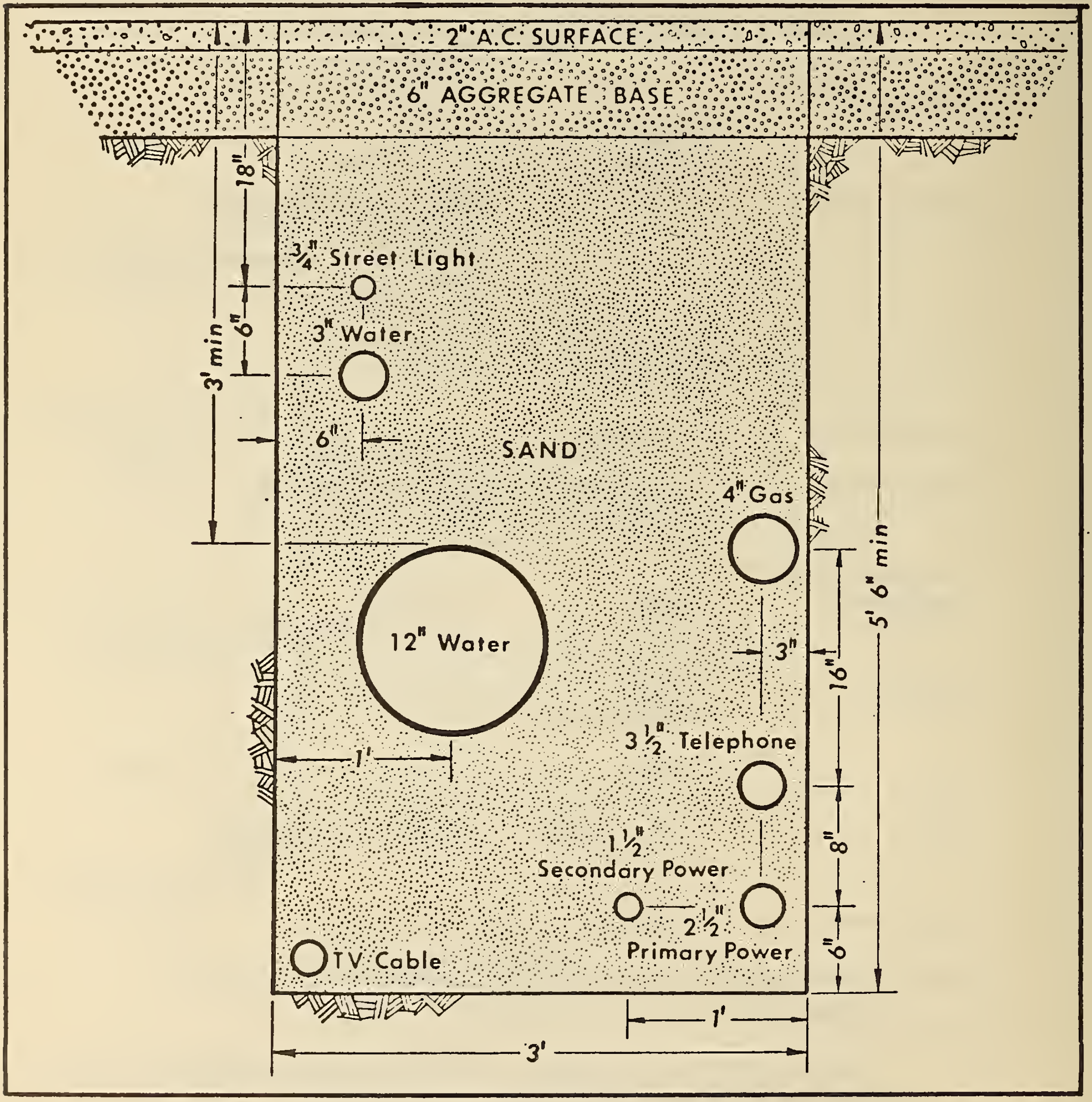


FIGURE 13 PROPOSED COMMON TRENCH UTILITY LOCATION

Des Moines Standard (Proposal): Figure 14, Proposed Location Underground Utilities, indicates the relative position recommended by the Underground Public Utilities Coordinating Committee, in 1972.

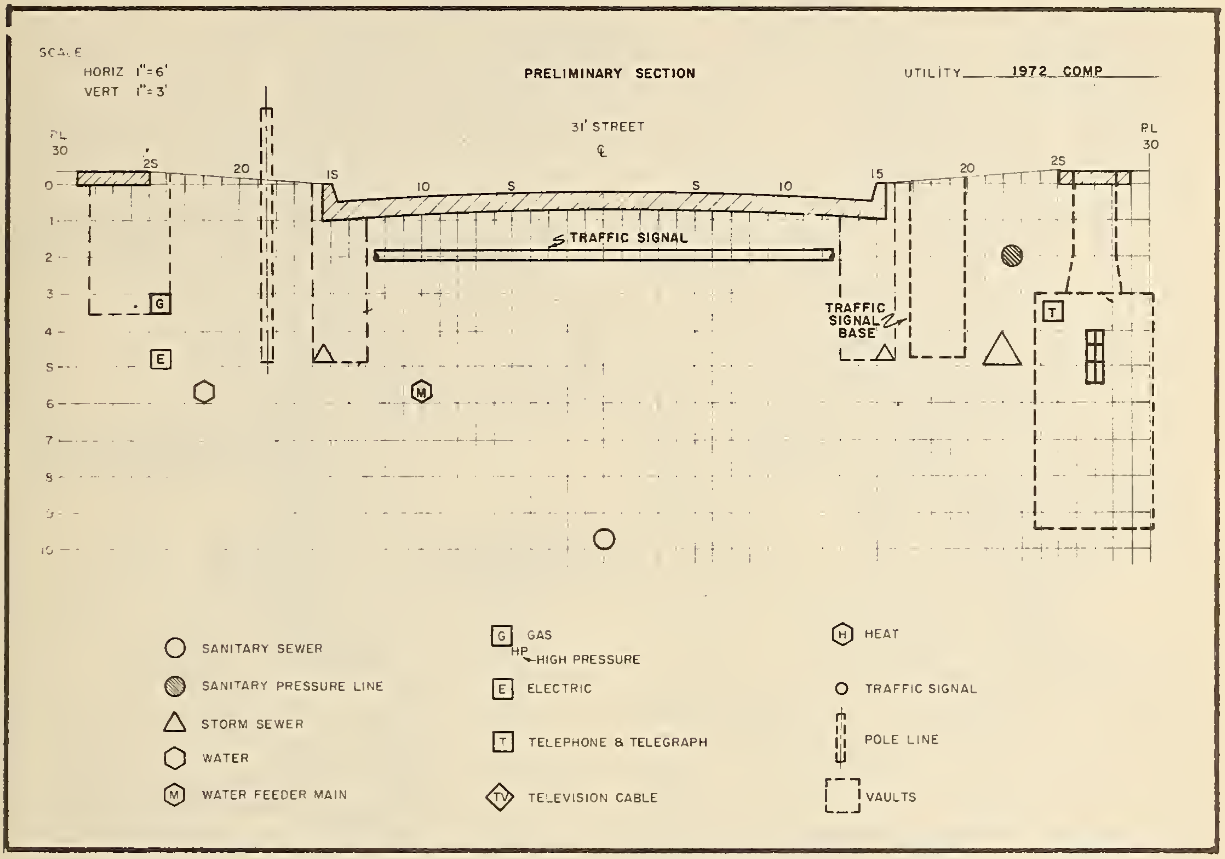
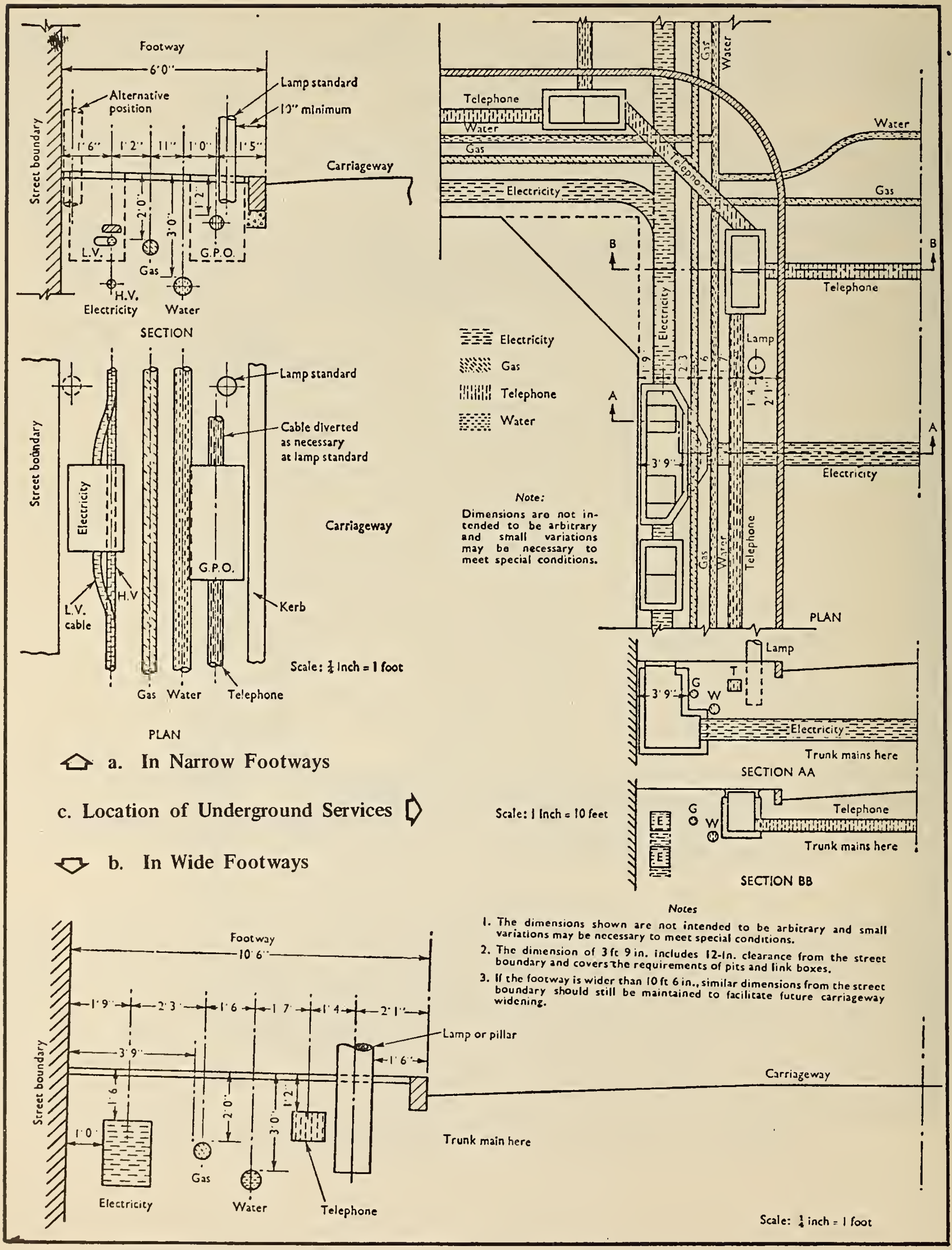


FIGURE 14 PRELIMINARY LOCATION OF UTILITIES
UNDERGROUND PUBLIC UTILITIES COORDINATING COMMITTEE
DES MOINES, IOWA

British Practice: The universality of the utility location problem is attested to by the studies and standards proposals made by the British Institution of Civil Engineering and the Institution of Municipal Engineers. The work of a joint committee representing both scientific organizations first evolved in the form of a report in July 1946; it was revised in December 1954, and in July 1963. Figure 15(a) and (b), Disposition of Mains, suggested layouts of utility mains in the underground in streets with wide footways and narrow footways is excerpted from the 1963 report to illustrate the British interest in locating utilities in the area which is referred to as under-the-sidewalk in American practice.



Note:
Dimensions are not intended to be arbitrary and small variations may be necessary to meet special conditions.

Notes

1. The dimensions shown are not intended to be arbitrary and small variations may be necessary to meet special conditions.
2. The dimension of 3 ft 9 in. includes 12-in. clearance from the street boundary and covers the requirements of pits and link boxes.
3. If the footway is wider than 10 ft 6 in., similar dimensions from the street boundary should still be maintained to facilitate future carriageway widening.

FIGURE 15 STANDARDS PROPOSAL, DISPOSITION OF MAINS BRITISH INSTITUTION OF CIVIL ENGINEERS AND INSTITUTION OF MUNICIPAL ENGINEERS

CHAPTER IX
IMPEDANCE EFFECT OF UTILITY CONSTRUCTION ON TRAFFIC

As a part of the study, an effort was made to determine the effects of utility plant and its servicing upon the flow of vehicular and pedestrian traffic, including comparative transportation costs and travel time, reflecting such factors, among others, as: operating costs of vehicles, travel times and speeds; time delays; peak hour traffic flow; accidents of all types; damages to pavements; vehicles; utility plant, and abutting property; storms and floods; detours, and travel distance. This objective was based on recognition of the need to determine traffic impedance costs associated with utility construction and maintenance activities.

Research Plan

A research sub-study was designed to investigate and quantify the effect of utility construction and maintenance activities on the flow of traffic on a variety of street types and under various conditions. Costs associated with motorist delay and vehicle operation were expected to be sizable relative to other cost considerations to be included in the total systems economic analysis. Two alternatives were considered for determining traffic impedance costs. The first alternative, working within a restricted budget, would provide for a limited number of highly structured on-site investigations to be conducted in only one major metropolitan area with a limited number of variables. The second alternative, and the one selected, involved a sizable number of representative public agencies conducting a much greater number of studies under a wide variety of situations.

The latter alternative was selected for two additional reasons, namely: original budget allocations for data collection needs could be utilized for analysis of a greater amount of data to be collected by several cooperating public agencies since the agencies would collect the field data at no cost to the project; and a representative geographical sampling would account for wide variations found among potential users of the study results.

A theoretical approach was considered. However, because of the complex nature of the problem of analysis of traffic flow on the urban street network and the many variables experienced among and within urban areas, it was determined that operational data should be collected from the real-life environment of urban areas selected throughout locations in the United States and Canada.

The traffic stream is not homogeneous with regard to either drivers or the influence of environmental factors, particularly under interrupted flow conditions typical of most highly traveled urban streets. Heretofore, no attempt had been made to measure the magnitude of the interrelating independent and dependent variables in the analysis of the impedance of traffic flow in urban street networks caused by utility construction and maintenance activities.

Previous investigations had developed a relationship between locations of continuous lateral obstructions, such as retaining walls and other street appurtenances and capacity, under uninterrupted flow conditions, as reported in the *Highway Capacity Manual* (pp 89-90). In cases of "spot" lateral restrictions, the manual implies but does not quantify, that such restrictions may not seriously affect traffic flow at lower speeds.

Along most urban streets there exists a variety of fixed traffic interruptions such as signalized intersections, stop signs, driveways and the like which impede the smooth flow of traffic. It is generally agreed that these friction points along a roadway contribute to a loss in the traffic-carrying capabilities of the street. Add to this the restrictive effect of most construction and maintenance activities, and it stands to reason that a further reduction in capacity may be expected. It was recognized, however, that it may not be noticeable on many urban streets where their capacity exceeds traffic volume demands. On the other hand, when demand exceeds the traffic-carrying capabilities of the street, significant delay may be expected. The *Highway Capacity Manual*, however, recognizes the limitations in determining *capacity* levels of service on urban streets, particularly on those located in densely developed areas such as are found in most downtown areas.

Recognition of the limitations of a study-wide application of a direct capacity-volume approach to analysis of traffic flows, particularly at non-intersectional locations in a variety of construction and maintenance situations on urban streets, ranging from those located in densely developed downtown areas to residential subdivisions, led to consideration of other means for quantifying the impedance effect of construction and maintenance activities on the traffic stream. It was concluded that vehicle operation and motorist delay lend themselves best to economic analyses. These included an evaluation of acceleration-deceleration events and other vehicle operation characteristics and a comparison of average overall travel time and number, causes and time of stops.

Data collection techniques necessary for this type of analysis are commonly employed by local public agencies in their regular traffic surveillance programs. Familiarity with the study techniques was a major reason for utilizing the "floating" test vehicle technique for determining average overall travel time; test vehicles were driven over the study routes according to the drivers' judgment of the average speed of all vehicles in the traffic stream. This required the test vehicle to pass as many vehicles which pass (overtake *and* pass in the same direction on multi-lane streets) the test vehicle. On multi-lane streets, the test vehicle alternated among lanes at the approach to the work area. Delay attributed to the construction-maintenance activities was to be determined by comparison of average overall travel times recorded under normal conditions and during the activity. Reference points (normally intersections) would provide for analysis and comparison of the results by either the immediate (short) section or the longer section which might include several blocks. In cases where it appeared that the point of critical density (the density of traffic when the volume is at capacity on a given roadway) had not been reached the immediate section was considered as being satisfactory for analysis purposes. However, when it was apparent the point of critical density was reached, upstream roadway sections would require special consideration. A detailed report of the study is contained in Appendix E, Traffic Delay Study.

Conclusions

The following conclusions are based on the results of the evaluation of field data:

1. *Objective:* A statistical correlation between numerous utility site and traffic characteristics (independent variables) and average overall delay (dependent variable) could not be found in studies of either short or long section lengths.

Subjective: The theoretical approach of using and transposing unlike data from site to site is questioned. Pure relationships are seldom found in the real-life environment. With the limited amount of usable data it was extremely difficult to hold all other independent variables constant when attempting to find a correlation between one independent variable, say street type, and the dependent variable of average overall delay.

2. *Objective:* Utility activities located in the travel portion of roadway have a more sizable impedance effect on signalized routes. The effect is even greater on signalized routes which are coordinated for traffic demands found under *normal* conditions. This is apparent in the evaluation of average overall delay either on the basis of individual study sites or all signalized study sites collectively. Traffic flow at 16 of the 32 study sites, where "like" data was compared, were influenced by traffic signal(s). The mean average overall delay for these sites was 13.6 seconds. The mean for the 16 sites *unaffected* by traffic signals was 6.0 seconds. Of the 32 sites, 13 were on one-way streets, and 19 were on two-way streets. Of the four sites found with relatively significant average overall delay, two were on two-way routes in outlying business districts, one on a one-way route in a CBD and one on a two-way route in a

residential area. Traffic volumes were not provided in the latter study site but other information indicates that the facility was a heavily traveled major arterial at the time of the study.

Subjective: In several cases the number of test-vehicle runs was limited. Other studies[1] have concluded that the moving-observer method of recording average overall vehicle travel times was best suited to medium and heavy traffic volumes, in which case the number of test runs required to achieve a given degree of accuracy can be relatively small. The validity of using limited data collected at certain study site locations is questioned since several of the sites were on lower volume facilities and/or influenced by traffic signals. Nevertheless, even if these "poor" sites were omitted from collective evaluation, the mean average overall delay would remain insignificant.

3. The term *significant* as used in this report has two applications. It is used in a relative sense in the objective case, while in other cases it is purely subjective. For example, 77.7 seconds of average overall delay were found at one study site, and this is objectively considered to be significantly *relative.* Considered by itself, it is left to the reader whether or not 77.7 seconds of average overall delay is considered as being significant. It is the opinion of the APWA Research team that the average overall delay found at some study sites *was* significant.

4. Good judgment must be used when restricting times of utility activities. The following serves as an example. It is not uncommon to find arterial streets leading to and from major traffic generators such as a central business district to carry large volumes inbound during the morning peak period, say 7:30 to 8:30 a.m., and relatively small volumes outbound during the same period. If the arterial is a four-lane two-way street and the two-lane capacity is adequate for inbound traffic demands and outbound traffic can be adequately served by the capacity of only one lane, then the remaining lane could be used for utility work without causing undue delay. It is not necessary that the utility work be performed in a *normal* outbound lane. Based on the findings of this study, little delay in this example would occur to inbound traffic which would be required to cross over the centerline when traversing the work area, assuming, of course, that proper construction signs, marking and barricades were provided.

Microanalysis of one study site with the work area located in a marked crosswalk at a signalized intersection found delay greater for vehicles traveling in the opposing direction. It was the subjective conclusion that the delay was caused primarily by the small width available for right turning vehicles entering the work area from the opposing direction.

5. Only a small number of work sites were located within the intersection and in those cases even a smaller number included travel time data on the side street. One study, although primarily located in a crosswalk, did involve barricades located immediately outside the outside lane in the intersection for side street traffic traveling in the critical direction. In that study, the delay was found to be significant. No studies were conducted at work sites located within intersectional through lanes.

The findings of the study must be carefully considered in any decision related to the location of utilities within urban street and highway rights-of-way. Recalling that work *areas,* not specific work sites, were studied, the manner in which construction or maintenance takes place may affect traffic flow more than does the specific location of the utility, assuming of course that the utility must be located within the travel portion of the roadway. For example, activity on a utility located in the right travel lane of a three-travel lane one-way street with parking on both sides under "normal" conditions may not seriously impede traffic flow if traffic volumes at the approach do not exceed the traffic carrying capabilities of the remaining two travel lanes. No problem should occur if the parking lane is utilized by construction or maintenance equipment. However, if the equipment utilizes, even intermittently, the center travel lane, in this example, then volume demands can be expected to exceed traffic-carrying capabilities and congestion will result.

The large majority of street mileage in urban areas easily accommodates traffic volume demands even during peak traffic periods. Generally speaking, it is only on streets with signalized intersections where attention should be directed towards traffic flow needs when a decision is needed related to locations of future utility lines or in maintaining existing utilities.

CHAPTER X
EVALUATION OF EXISTING PRACTICES

A major goal of the study of the accommodation of utility plant within the rights-of-way in urban areas was to identify pertinent factors which might be used as a basis for the development of new methods and techniques, and as criteria by which to judge the effectiveness of present practices.

Many diverse practices were found and have been reported upon. Few, however, could be classified as new inasmuch as they have been used in various forms for many years. Rather, it appears that the problems inherent to technology transfer have minimized adoption of many of what appear to be "advanced" techniques such as joint trenching and conduit systems.

Technology transfer appears to have been inhibited due to the:

1. multitude of utilities involved
2. various regulating bodies involved
3. the utility plant is often out of sight
4. there have been relatively few forums to transfer information across the board, as opposed to intra-utility communication.

Above ground, where conflicts of poles and lines have become highly visible, cooperative programs have been undertaken to share these facilities and to make more efficient use of space. Likewise, in new developments where requirements for financing have mandated undergrounding, much has been accomplished.

For new developments and major redevelopment, adequate methods and precedents are available which appear to allow a standardized approach to utility plant location. Economics and the determination of cost to each user (utility) may restrict the use of the *best* practice for the overall interests of the public. Therefore, government may very well need to go beyond the general cooperative efforts of the present and develop additional mandatory requirements. Such additional requirements are not necessarily recommended by this report; rather they appear inevitable.

Many of the problems which have been reviewed in this report appear to be the result of insufficient permit and inspection services by many public agencies. Few agencies have had adequate funds to enforce permit and inspection programs. In a large measure this appears to be the result of low fee schedules which do not cover the cost of the service provided, and the inability of agencies to convince their legislative bodies of their manpower and equipment needs.

The second major need is the development of a coordinating mechanism to allow all utilities to work in concert. Many agencies have formed coordination committees as described in Chapter VI.

The third element is a call-before-you-dig program. Such a program is needed, no matter how effective the other two programs are, to ensure that job site safety is provided and as additional insurance to each utility that its physical plant will be protected by field forces.

Field services must be provided by each utility. Table 19, Field Service Practices, indicates that most utilities provide field location service, although such efforts are limited when records are the main source of information. Roughly 15 percent uncover their plant, the most dependable method of utility location and protection.

TABLE 19
FIELD SERVICE PRACTICES

Utility	Field Location Service Provided	Typical Method Used (%)		Plant
	No. Yes %	Records	Instruments	Uncovered
Water	98	71	6	14
Sewer	96	91	17	14
Gas	97	64	67	15
Telephone	97	67	56	13
Power	95	77	46	13
Other	13	79	58	29

Source: Survey of 222 agencies, 1973, by APWA

As each local agency evaluates its program, consideration of the following factors is appropriate.

Safety – Each utility should meet the equipment standards set by the industry. Clearances required by the physical functioning of the individual plant (i.e., heat loss, electrical interference, etc.) or required to maintain the plant, must be maintained.

The public in general, and workmen in particular, must be protected from accidents. Federal, state and local standards must be observed.

The users of the surface must also be protected and accident potential must be minimized. Strict adherence to signing and barricading regulations as well as other safety requirements must be insured. Pavement restoration must be expeditiously accomplished and pavement hazards avoided.

Social – Preplanning and high standards will do much to minimize social inconvenience to the public. Access to major vaults or manholes should be out of the traveled way wherever possible. Undergrounding of utilities will minimize service interruptions due to damage to overhead plant. Service appurtenances should be engineered so that they are not a physical hazard or aesthetically displeasing. Joint poles for overhead plant should be required.

Environmental – The environmental impact of multiple trenching, repeated street openings and early failure of the street surface should be avoided. Ducting systems, particularly those placed outside of the travel-way appear particularly desirable. As an alternative, joint trenching is being used successfully in many areas. Although the administrative burden to coordinate construction is much greater with joint trenches, its advantages appear to be such that it must receive wider use.

Standard Location – Standards for the location of each utility are desirable, particularly for a metropolitan or regional area. Many agencies have established standards for new areas and seek to work toward the standards in older areas as plant is replaced. At first thought, it might appear reasonable to develop nation-wide standards for various classes of streets and mixes of utilities. However, as an economic model is prepared upon which such space allocations might be made, it becomes evident that there is little commonality among communities or agencies.

From the standpoint of individual utilities, a great many of the judgements which must be made by government in the coming years will be classified as arbitrary – that is, not dictated by either safety or economics for the individual utility but by the overall best interests of the public to be served.

APPENDIX A
STANDARD FORMS AND LETTERS OF APPLICATION

EXHIBIT 1

CITY OF WINNIPEG
Engineering Department

APPLICATION FOR PERMIT

To the City Engineer:

I hereby apply for permits as follows:

_____Building Grades ______________________________ _______ _______
_____Sewer Connection Permit under Sewer By-law ______________ _______ _______
_____House Moving Permit __________________________ _______ _______
_____Conduit Permit _______________________________ _______ _______
_____Poles Permit ________________________________ _______ _______
_____Use of Street Permit under Building By-law _______________ _______ _______
_____Boulevard Replacement Permit _______ Sq. Yards at __________ _______ _______
_____Workmen's Closet Permit under Health By-law ______________ _______ _______
_____Water Connection Permit under Water Works By-law __________ _______ _______
____ _______ _______
____ _______ _______
____ _______ _______
_______ _______

TOTAL $ ____________

1. No. ______ Location: ________ Side: ______________ Street, between: __________
and ______________________ Sts. Lot: ________ Block: ________ Plan: ________ DGS: ___
2. Name of Owner: ______________________ Address: ______________________
3. Name of Architect: ______________________ Address: ______________________
4. Name of Builder: ______________________ Address: ______________________
5. Sewer Contractor: ______________________ Address: ______________________
6. Purpose of Building: ____________________________ No. of Rooms: __________
7. Size of Building: ______________ Storeys: ____________ No. of Families : ________

REMARKS: ____
____

I undertake to observe and perform the provisions of all Federal or Provincial statutes or regulations, all by-laws of the City of Winnipeg and of the Metropolitan Corporation of Greater Winnipeg and all specifications or instructions issued by the duly authorized officers of the City in respect of the work incidental to the subject matter of this application and to indemnify the City against all loss, costs, charges or damages caused by or arising out of anything done pursuant to any permit issued under this application.

______________________________ Firm
______________________________ Signature

PERMIT AND RECEIPT

Winnipeg, ________________ 197__

THIS certifies that ____

is granted permits to do the work described in and for the purpose shown in the above application and that payment has been made for the said permits in the manner and the amount as shown by the cash register impression hereon.

Each permit is granted subject to the terms of the said application and subject to the provisions of the City's by-laws hereinbefore mentioned, and nothing permitted hereunder shall be deemed to override the provisions of any applicable by-law of the City or the Metropolitan Corporation of Greater Winnipeg or any statute or regulation of the Government of Canada or the Province of Manitoba.

These permits shall expire if active work is not commenced and reasonably continued within three months from the date hereof.

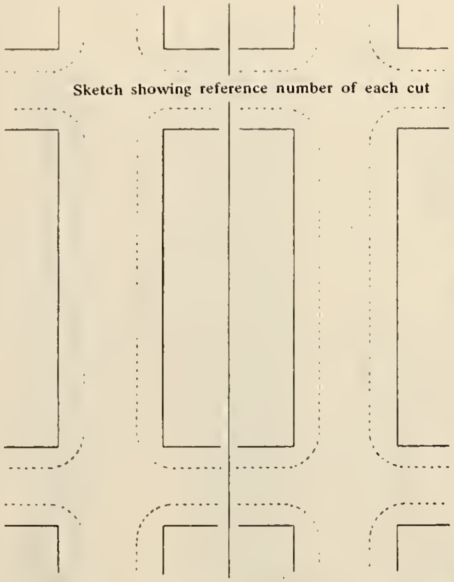
W. D. HURST, City Engineer.

Per ______________________

This permit DOES NOT CONFER upon the permittee or owner the right to establish an approach from the public street to serve the premises. Such approach requires special permission. Application for an approach must be made to the City Engineer.

EXCERPT FROM BY-LAW No. 16225: "No person shall throw, pile, deposit or leave . . . material of any kind . . . upon any street or lane."

EXHIBIT 1 *(continued)*



Sketch showing reference number of each cut

ARRIVAL TIME	DATE	

WARNING: READ THIS BEFORE YOU BEGIN WORK. If power equipment or explosives are to be used for the excavation authorized by the attached permit, no work shall be commenced BEFORE: 1. The local office of the gas company has been notified of the proposed excavation, and 2. The gas company has marked out the location of any endangered gas installations, OR the gas company has advised that no gas installations will be endangered by the proposed excavation. For specific details refer to Manitoba Regulations 210/72 made under The Gas Pipe Line Act.

LOCATION ______ 37944

TO THE AREA ENGINEER (INNER CITY)

I Hereby apply for the following permits: Date ______

Street Truck Route ______

Residential ______ ______

Concrete Walk Cuts ______ ______

Curb Cuts ______ ______

Curb & Gutter Removal ______ ______

Graded Street Cuts ______ ______

Mud Cuts ______ ______

Pole Permits ______ ______

Applicant ______ $______

Address ______

I undertake to observe and perform the provisions of all Dominion or Provincial statutes or regulations, all by-laws of the City of Winnipeg and all specifications or instructions issued by the duly authorized officers of the City in respect of the work incidental to the subject matter of this application and to indemnify the City against all loss, costs, charges, or damages caused by or arising out of anything done pursuant to any permit issued under this application.

______

Signature

PERMIT AND RECEIPT

THIS certifies that the above named applicant is granted permits to do the work described in and for the purpose shown in the above application and that payment has been made for the said permits of the amounts shown by the cash register impression hereon.

Each permit is granted subject to the terms of the agreement contained in the said application and subject to the provisions of the City's by-laws hereinbefore mentioned, and nothing permitted hereunder shall be deemed to override the provisions of any applicable by-law of the City or any statute or regulation of the Dominion of Canada or the Province of Manitoba.

These permits shall expire if active work is not commenced and reasonably continued within three months from the date hereof.

Area Engineer
Per ______

EXHIBIT 2

County of ______Div.___
S. R. ____________Sec. ____

STATE OF OHIO
DEPARTMENT OF HIGHWAYS

APPLICATION FOR PERMIT
See Instructions on Back of Sheet

To the DIRECTOR OF HIGHWAYS
Columbus, Ohio

DATE ____________

Dear Sir:

Application is hereby made by (1) ____

P. O. Address (2) ____

to (3)____
____
____
____

at the following described location (4) in ____________________________ County along across S.R. No.________
____
____

and in accordance with the attached plan (5).

(6) Work will commence on or about ____________________________________ and will require ______________________________days.

(7) If the proposed installation requires the opening of the pavement give the following information.

A. Conditions necessitating opening of pavement ______________________________________
____

B. The opening to be made in the pavement will be________ feet long by __________________ feet wide and __________________ feet deep.

C. Pavement is to be replaced by:

(a) ____ as directed by and to the complete satisfaction of the Division Deputy Director,

(b) Certified check for ______________________________________ dollars ($_____________) being enclosed to cover cost of the pavement replacement (as per schedule on back of this sheet) if permit is granted.

I

(8) We hereby agree to backfill the trench of said opening by thoroughly tamping the backfill in four (4) inch layers; also to tamp in the top of that part of said trench which is in the travelled road, and place a minimum of six (6) inches of coarse aggregate or a minimum of three (3) inches of pre-mixed material as a wearing surface; and to maintain the road surface which has been disturbed until such time as the pavement can be replaced by or to the satisfaction of the Department of Highways.

I

(9) We also hereby agree to maintain lights, signs, barricades, flagmen, and watchmen necessary for the protection of traffic at all times, day and night, during the work provided for under this permit, and that such instructions given by the Division Deputy Director as to handling of traffic will be fully complied with.

I

(10) We agree to comply with all the conditions, restrictions and regulations of the Department of Highways.

____

By______________________________

EXHIBIT 2 *(continued)*

TO BE FILLED IN BY DIVISION DEPUTY DIRECTOR:

S.R. No. ____________ **SECTION** ____________ **COUNTY** ____________

WIDTH OF R/W ____________ **FEET WIDTH OF PAVEMENT** ____________ **FEET**

POSSIBLE FUTURE EXPANSION ____________

TYPE OF SURFACE ____________ **THICKNESS** ________ **BASE** ________ **THICKNESS** ________

DIVIDED LANE ____________ **RAISED CURB** ____________ **BERM WIDTH** ________

LIMITED ACCESS ____________ **SHALL PERMIT BE GRANTED** ____________

WHAT, IF ANY, ADDITIONAL REQUIREMENTS ARE TO BE IMPOSED ____________

____

____

Division Deputy Director

INSTRUCTIONS

(1) Owner of proposed installation (application by contractor not acceptable).

(2) Mailing Address of Owner.

(3) State fully and completely type of installation proposed.

If pole line give the following information:

Number of poles, total length of line, type of wire, character of service, vertical clearance over pavement, and voltage if power line.

If pipe line give the following information:

Type of service (water, oil, gas, sewer – sanitary or storm, etc.); if carrying liquid or gas under pressure, state pounds per square inch, internal diameter and kind of pipe, length of line and proposed location with respect to pavement or right of way line; if pipe or conduit is to cross highway and crossing cannot be made without disturbing pavement advise conditions requiring such method of installation.

If access approach give the following information:

Use to be served (private, industrial, or commercial); if not private, advise kind of industry or business. Type of construction, width, thickness and drainage data.

(4) Give County, State Route, and distance from some geographical point, such as intersecting state highways, city or village corporate limits, section lines, county or township highways.

(5) Attach four (4) copies of a plan showing proposed location of installation with reference to pavement, right of way line, and owner's property lines. If installation crosses the highway, show cross section of present roadway and proposed installation. Plan should also show information listed under item (4).

(6) Give anticipated dates for beginning and for completion of proposed installation.

(7) No tunnelling will be permitted, and any installation which cannot be made without opening the pavement requires the applicant to reimburse the State for costs in replacement of the pavement or to replace the pavement at his or their own expense and to the satisfaction of the Division Deputy Director.

A. State conditions preventing installation under pavement by driving or boring.

B. Give specific dimensions since pavement replacement costs will be checked against information.

C. A certified check, payable to Treasurer, State of Ohio, must accompany application for opening pavement, if pavement is to be replaced by State forces. The amount of the check shall be based on the following schedule offees for the type of pavement to be replaced as shown on straight line diagram or other records on file in the Division office.

LIST OF PRICES CHARGED FOR PERMITS TO CUT INTO A STATE ROAD

The charges for cutting into the road will be: $40.00, plus the following rate per foot and square yard for the particular type of road surface as given below:

TYPE OF ROAD SURFACE		
Cement Concrete, Asphaltic Concrete (T-35 on Rigid or Flexible Base and Brick	For each lineal foot of pavement to be replaced when the width is eighteen inches or less	$ 4.00
	For each additional square yard cut	12.00
Bituminous Road Mix (T-32) or Pre Mix (T-34) on Flexible Base	For each lineal foot of pavement to be replaced when the width is eighteen inches or less	$ 2.50
	For each additional square yard cut	7.50
All Other Low Type Surfaces and Bases	For each lineal foot of pavement to be replaced when the width is eighteen inches or less	$ 1.00
	For each additional square yard cut	3.00

STATE OF OHIO
DEPARTMENT OF HIGHWAYS
PERMIT

Subject to all of the terms, conditions and restrictions printed or written below, and on the reverse side hereof, permission is hereby granted to

This permit to be in possession of employees in charge of work at all times. To be shown upon request to any employee of the Department of Highways.

No work shall be done under this permit until the party or parties to whom it is granted shall have communicated with and received instruction from Mr. ______________________________

Division Deputy of the Department of Highways, ______________________________

____

This permit shall be void unless the work herein contemplated shall have been completed before

____

Dated at Columbus, this ____________ day of ______________________________, 19____

____

Director of Highways

GENERAL PROVISIONS IN FORCE INSOFAR AS THEY APPLY TO THE WORK TO BE DONE UNDER THIS PERMIT

Conditions Relating Particularly to Permits for the Laying of Pipes, Conduits, Etc.

After any pipes, conduits, drains or other underground structures are laid or any excavation is made in the roadway, the trenches or openings shall be properly backfilled with suitable material, the material shall be placed in courses not to exceed six (6) inches, loose measurement. Each course shall be thoroughly tamped or rolled, and shall be firm and uniform or backfilling may be made as directed by the Division Deputy Director of Highways (Division Engineer).

Material satisfactory to the Division Deputy shall be used as the final course, so there will be a firm and solid surface. In no case shall the material so placed be allowed to project above or below the grade of the road as originally established. All surplus material shall be removed in a manner satisfactory to the Division Deputy. The permit holder shall maintain the berm over the trench in a manner acceptable to the Division Deputy for the period of one year.

If the work performed is under the pavement, it will be required that any portions removed in excavating or damaged in the progress of the work, with the exception of the road base and surface, shall be replaced in accordance with the above section. It is required that the permit holder notify the Division Deputy of the day on which the opening of the pavement will be made, also the time of completion of the backfill.

Whenever the pavement is disturbed it will be replaced by the State Highway Department and the cost of such work shall be borne by the permit holder. Until such time as the road base and surface shall have been replaced by the State Highway Department any cost of maintenance of keeping the highway in passable condition shall be borne by the permit holder.

At all times during the progress of the work, adequate protection and passage shall be provided by the permit holder for the traveling public. Not more than one-half of the traveled roadway shall be closed at one time; such barriers shall be erected and maintained as may be necessary for the protection of the traveling public; the same shall be properly lighted at night; and the party or parties to whom this permit is issued shall be responsible for all damages to persons or property due to or resulting from any work done under this permit.

No tunneling shall be done under this permit; where pipes or conduits are to cross the highway, the crossing shall be made without disturbing the pavement, by driving the pipe under the roadway; the pipe shall be carried under and across the road in a larger pipe or casing unless otherwise herein provided or by written consent of the Division Deputy.

When manholes are placed in the berm of the highway they shall be located at such depth that the berm can be maintained over the top of the same. If at some future time the pavement is widened over the conduit, the manholes shall be raised to conform with the surface of the pavement.

The pavement shall be kept clear of all dirt from the excavation. In the event the highway becomes damaged because of said construction, the party or parties to whom this permit is granted shall promptly restore said highway to its former state of usefulness.

All of the above conditions shall apply in event it becomes necessary to open the trench at some future date for repairs or removal of structures.

Conditions Relating Particularly to Permits for the Erection of Poles, Wires and Overhead Structures

1. In the erection of pole lines, unless otherwise herein provided, or by written consent of the Division Deputy, the center of all poles shall be located not more than one foot inside the right of way of the highway.
2. No cutting or trimming of trees is authorized by this permit; in case it is found necessary to trim trees within the boundaries of the highway, the least amount possible shall be done, and in all cases the consent of the abutting property owners must be secured before poles are set and trees trimmed.
3. When the poles are side guyed across the highway, the stub to which the guy is attached shall be located not more than one foot inside the right of way line; the vertical clearance between the guy and the edge of the pavement farthest from the pole being guyed shall be not less than 14 feet.
4. When "A" pole, "H" pole or a brace pole construction is used not more than one of the poles shall be set on the highway right of way.
5. All pole lines are to be built in accordance with Administrative Order No. 72 of the Public Utilities Commission of Ohio.

General Provisions Applicable to All Permits

During the progress of the work such barriers shall be erected and maintained as may be necessary for the protection of the traveling public; the same shall be properly lighted at night; the party or parties to whom this permit is issued shall be responsible for all damages to persons or property due to or resulting from any work done under this permit.

Except as herein authorized, no excavation shall be made or obstacle placed within the limits of the highway in such manner as to interfere unnecessarily with the travel over the road.

If any grading or sidewalk work done under this permit interferes with the drainage of the highway in any way, such catch basins and outlets shall be constructed as may be necessary, in the opinion of the Director of Highway, to take proper care of said drainage.

If the party or parties to whom this permit is issued does anything contrary to the orders of the Division Deputy and after due notice fails to correct such work or to remove such structure or material as he or they may be ordered to remove, the Department of Highways may, with or without notice, correct such work or remove such structures or material; and the party or parties to whom this permit is issued shall reimburse the Department of Highways for any expense incurred in correcting the work or removing the structure or materials.

All the work herein contemplated shall be done under the supervision and to the satisfaction of the Department of Highways and the entire expense thereof shall be borne by the party or parties to whom this permit is issued.

On the completion of the work herein contemplated all rubbish and debris shall be removed and the roadway and roadsides shall be left neat and presentable and satisfactory to the Division Deputy.

The granting of this permit does not in any way abridge the right of the Director of Highways in his jurisdiction over the state highways. If, in the process of any future work or for the benefit of the traveling public, it becomes necessary, in the opinion of the Director of Highways, to order the removal, reconstruction, relocation or repair of any of the fixtures, or work performed under this permit, said removal, reconstruction, relocation or repair shall be wholly at the expense of the owners thereof, and be made as directed by the Director of Highways.

The right reserved, during the time any or all the work is being performed, to appoint an inspector over the work who shall represent the interests of the State on the work, and any compensation arranged for shall be paid wholly by the permit holder.

All of the above conditions shall be applicable to the work herein authorized, unless the same are inconsistent with the conditions on the face of the permit, in which case the conditions written or printed on the face of the permit shall apply.

The acceptance of this permit or the doing of any work thereunder shall constitute an agreement by the party or parties to whom the permit is granted to comply with all of the conditions and restrictions printed or written herein.

This permit may at any time, be revoked and annulled by the Director of Highways for non-performance of or non-compliance with, any of the said conditiosn, restrictions and regulations hereof.

EXHIBIT 3
City of Minneapolis

III. GENERAL PROVISIONS

1. Street space is at a minimum so no more space should be used for construction work than is absolutely necessary. Through barricading and channelization the remaining street space is used to carry the traffic around the construction area in the best way possible.
2. Traffic control devices shall be set up prior to the start of construction or maintenance operations and shall remain in place only as long as needed. They shall be maintained by the contractor or department doing the work.
3. Signs with messages that are applicable at night shall be reflectorized or illuminated. Existing street lighting shall not meet the requirements of sign illumination.
4. At night adequate artificial lighting devices are needed to call attention to and to indicate the actual location of obstructions and hazards.
5. Equipment when not in use during work hours or parked at night shall not be left in such a manner as to block the motorist's view of traffic signs and signals.
6. The minimum width for temporary traffic lanes is 10 feet but 12 feet is advisable and should be used wherever possible.
7. Whenever traffic must be routed over the centerline, the two directions of traffic flow must be physically separated. Traffic cones can be effectively used for this purpose during daylight hours; steady burning lights at night.
8. The peak flow of traffic occurs in Minneapolis between the hours of 7 to 9 AM and 3:30 to 6 PM During these hours, maintenance work which encroaches into a moving lane of traffic will not be allowed on arterial streets except during emergency conditions or with the approval of the City Traffic Engineer.
9. In situations not covered in this manual, the protection of the traveling public and the protection of the workmen on the scene will dictate the measures to be taken consistent with the general principles presented here.
10. Where a complete street closure is necessary, the City Traffic Engineer will set up and sign an alternate route. At least seven (7) working days advance notice shall be given the Traffic Engineering Division in such a case. Confirmation of the proposed closure shall be given the Traffic Engineer three (3) working days in advance of the actual street closure.
11. The City of Minneapolis Department of Public Works and/or Traffic Engineering Division is authorized to stop any construction or maintenance activity which is not properly signed and barricaded as required by this manual until such requirements are met.
12. When the work area encroaches upon a sidewalk, walkway or crosswalk area, special consideration must be given to pedestrian safety.

Protective barricades, fencing, handrails and bridges, together with warning and guidance devices and signs, must be utilized so that the passageway for pedestrians is safe and well defined.

Walkways in construction areas shall be maintained at least four feet in width and free of abrupt changes in grade. Obstructions within the walkway shall be illuminated during hours of darkness.

Where walks are closed by construction, an alternate walkway shall be provided, preferably within the boulevard. Where it is necessary to divert pedestrians into the parking lane of a street, barricading shall be provided to separate the pedestrian walkway from the adjacent traffic lane. Where no alternate walkway is possible, approval by the City Traffic Engineer of the pedestrian routing plan shall be obtained. At no time shall pedrestrians be diverted into a portion of the street used for vehicular traffic. Any deviation from the above must have prior approval of the Department of Public Works and the Traffic Engineering Division.

At locations where adjacent alternate walkways cannot be provided, appropriate signs must be posted at the limits of construction and in advance of the closure at the nearest crosswalk or intersection to divert pedestrians across the street.

EXHIBIT 4

COMMONWEALTH OF PENNSYLVANIA
Department of Transportation

Bureau of Maintenance
(Central Permit Office)

GENERAL PROVISIONS AND SPECIFICATIONS
Regulating Occupancy of State Highway Right-of-Way

GENERAL PROVISIONS

"20. Maintenance and protection of traffic for work authorized by this occupancy permit must be carried out in accordance with the requirements of the Pennsylvania Department of Transportation. In this connection, the permittee shall provide and maintain all necessary precautions to prevent injury or damage to persons and property from operations covered by this permit. A traffic control plan may be required as directed by the District Engineer.

  a. Warning signs shall be placed beyond each end of the actual operation in such a manner as to be visible to the traveling public and meet the requirements of the Pennsylvania Department of Transportation. These signs shall display the name of the permittee and/or its contractor on the back of the sign. Special employees shall be assigned by the permittee and/or its contractor to direct traffic when it becomes necessary to limit it to one way. Advance permission must be obtained from Commonwealth, or its authorized representative before directing traffic through one lane. Substantial barricades with adequate illumination shall be provided and maintained for any open trench or hole in the highway right-of-way in a manner approved by the Commonwealth.

  b. Flagmen will be provided as specified and in accordance with the requirements of the Pennsylvania Department of Transportation."

EXHIBIT 5

CITY OF TORONTO, ONTARIO

a. Traffic Requirements
Vehicular Traffic

In order to provide a safe and effective work area, when temporary disruption of vehicular traffic is necessary, the basic principles and standards set forth in the City of Toronto Department of Public Works' "Manual on Street Signing and Channelization for Temporary Traffic Control" shall be observed, wherever applicable.

Pavement cuts, in heavily travelled streets, shall be plated during rush-hour periods, 7:00 a.m. to 9:00 a.m. and 4:00 p.m. to 6:00 p.m., and when work is finished for the day. Rush-hour work restrictions will be extended to 9:30 a.m. and commence at 3:30 p.m. on certain streets near Toronto Transit Commission's carports and garages in order to get T.T.C. vehicles "out of" and "in to" service.

Steel plates shall be of sufficient strength and rigidity to support vehicular traffic and be secured to the roadway in a manner that no movement will occur under traffic.

When two or more traffic lanes are to be excavated, plates shall be used so as not to obstruct more than one lane at a time.

Plates shall be placed flush with adjacent pavement. Paving materials shall be used, if necessary, to feather the edges of the plates to minimize wheel impact.

It is essential that the contractor has an adequate supply of plates at the job site before commencing work.

All temporary traffic lanes shall not be less than 11 feet in width unless otherwise authorized by the Commissioner of Public Works.

Construction equipment not actively engaged in the work shall be restricted to one side of the street only and shall not be parked in the work area, in a manner that would further restrict traffic flow, or create a visibility obstruction. Storage construction spoil or materials shall be treated in a similar manner.

Vehicles of the Contractor's employees engaged in the project will not be permitted to be parked within the area of construction.

The Commissioner of Public Works and Metropolitan Police Department can instruct the use of flagmen or policemen to control traffic through a work area.

Where flagmen are required, the contractor shall provide one man for each direction of traffic affected. Generally, flagmen are required where only one lane is available for two directions of traffic or when construction equipment blocks a traffic lane intermittently during the performance of the work. Capabilities of flagmen, details of distinctive clothing for day and night use, upkeep of signalling devices shall be in accordance with the requirements outlined in the Manual.

Pedestrian Traffic

Every precaution shall be taken to ensure that construction work does not interfere with the movement of pedestrian traffic, which shall be maintained on the sidewalk at all times and flagmen provided for guidance, as necessary.

Where an excavation interrupts the continuity of the sidewalk, the contractor shall provide suitable bridge or deck facilities, to be supplemented by the use of such proper devices and measures as prescribed in the aforementioned Manual, for the safe and uninterrupted movement of pedestrian traffic. The edges or ends of the pedestrian bridge or decking shall be bevelled or chamfered to a thin edge to prevent tripping.

Temporary diversion walkways shall be hard surfaced and electric lighting shall be provided and kept continuously burning during hours of darkness, when required by the Commissioner of Public Works.

Unless otherwise authorized by the Commissioner of Public Works, pedestrians shall not be directed to walk on the travelled portion of a roadway.

Under certain conditions, it may be necessary to divert pedestrians to the sidewalk on the opposite side of the street. Such crossings shall only be made at intersections or marked pedestrian crossovers.

Facilities satisfactory to the Commissioner of Public Works shall be provided for pedestrians crossing at corners, pedestrian crossovers and public transportation stops.

APPENDIX C
CONSTRUCTION STANDARDS FOR BACKFILLING

EXHIBIT 6

COMMONWEALTH OF PENNSYLVANIA
Department of Transportation
Bureau of Maintenance
(Central Permit Office)
excerpts from

GENERAL PROVISIONS AND SPECIFICATIONS
Regulating Occupancy of State Highway Right-of-Way
SUBSURFACE OPERATIONS

21. Any opening or impairment of any nature whatsoever of any improved surface within the state right-of-way as authorized by Departmental permit of any kind shall be made in accordance with the following specified provisions:
    a. Plates or bridging will be required on all openings made within the improved surface which have a shortest dimension in length or width of six (6) feet or less whenever work cannot be completed prior to peak traffic hours within the same day, or in the manner specified on the permit, Form 945P. The plate or bridging is to be extended a minimum of eighteen (18) inches on either side of the opening and tied into the existing cartway.
    b. A marker for identification showing the name of the permittee or a symbol assigned to the permittee shall be placed at each opening or impairment made for service installations or repairs within the improved surface of state highways. It shall be placed at the nearest edge of the cut closest to the edge of the improved surface and shown on plans attached to the application. Form 945A.
    c. The permittee is responsible for all costs and expenses of making and maintaining temporary or permanent restorations of disturbed areas. When permanent restoration is made the permittee shall be responsible for such areas for any subsequent failure of the highway surface during a period of two (2) years following completion of the permanent restoration work.
22. No openings for the purpose of placing pipe lines or other structures under the improved surface of the road or highway by drilling, boring, driving or tunneling shall be made closer than three (3) feet to the edge of the road metal, and trenches for conduits, water, steam, oil, gas pipes, sewers, and other obstructions placed parallel with the road or highway shall be dug so that the near edge of the trench is at least three (3) feet outside of the edge of the road metal with a minimum depth of three (3) feet below the surface of the road or highway unless the Commonwealth shall authorize in writing a lesser clearance. A greater distance shall be used wherever practicable.
23. In case the road or highway is not paved the trench shall be placed so that its near edge is at least fifteen (15) feet from the general center lines of the traveled road or highway unless authorized as provided in Paragraph 22. The center line shall be determined by the Commonwealth or local authorities.
24. The trench for such construction shall not be opened for a distance of more than five hundred (500) feet at any one time, unless especially authorized by Commonwealth. At no time will the permittee be permitted to leave more than one hundred (100) feet of trench open at the end of a working day whenever utilizing the shoulder of a state highway for the utility.
25. In case it is necessary to cross under any improved road or highway, the opening for a pipe line shall be drilled, bored, or driven on a horizontal plane at a minimum depth of three (3) feet below the surface of the road or highway, or the structure may be placed otherwise by tunneling when approved by the Commonwealth. Trenching will be authorized by the Commonwealth, in writing, where tunneling would be attended with danger to life. Where necessary to cross the improved road or highway by tunneling, the crossing shall be made, except in solid rock formation, under one-half of the improved road width, and the pipe or structure placed and the hole carefully backfilled with 1:3:6 concrete of a dry consistency thoroughly tamped, and allowed to stand twenty-four (24) hours before traffic is permitted to use that half of the road. The second half of the tunneling is to be completed in the same manner so that at least one-way traffic will be maintained over one-half the improved road or highway while the second half is being tunneled. In solid rock formation the crossing may be made by trenching when approved by the engineer representing the Commonwealth, but not more than one-half of the width of the pavement shall be opened, the structure placed, the trench backfilled and tamped with an approved mechanical tamper, unless other methods are approved, before disturbing the remaining one-half of the road.

26. Where a tile drain or other structure or facilty is encountered, it shall be replaced or restored by the permittee and/or its contractor in accordance with the prevailing standards of the Commonwealth.
27. The permittee and/or its contractor shall place the top of manholes so that it shall be even with the elevation of the highway and slope of its shoulder, unless a lower elevation shall be approved.
28. All excess excavated material shall be removed and disposed of outside the legal limits of the highway as the work progresses, unless the approval of the Commonwealth is obtained for disposal of the material within the legal limits of the highway. All parts of the highway and various structures disturbed shall be restored to a condition equal to that which existed before starting the work. Guard rails shall be replaced to the present alignment, and any guard posts discolored through the work of the permittee and/or its contractor shall be refinished by washing or repainting.
29. All openings required to be made in the cartway or road metal of a state highway for the installation, renewal or repair of a utility including utilities under the control or owned by a municipality shall be made pursuant to permit, or written authorization issued by the municipality, by the Pennsylvania Department of Transportation in accordance with the following requirements on backfilling and pavement replacement.
    1. Flexible Base Pavement –
        - a. Surface placed five (5) years or less prior to permit application

          Suitable material from the excavated trench must be retained to provide insulation around and over the utility to a height not to exceed twelve (12) inches over the top of the pipe, conduit, etc. This material shall be compacted in four (4) inch layers. This material shall be placed or stored on the side of the operation farthest from the road metal or pavement, unless otherwise authorized by the Commonwealth, and in such a manner that there will be no interference with the flow of water in any gutter, drain, pipe, culvert, ditch, or waterway. The remaining excavated material must be removed from the site unless said material meets specifications for No. 2 RC minimum. The trench must then be backfilled with No. 2 RC aggregate or suitable material meeting specifications for No. 2 RC minimum compacted in layers not to exceed four (4) inches using a mechanical tamper up to the bottom elevation of the pavement structure. The No. 2 RC aggregate or suitable material meeting specifications for No. 2 RC minimum must meet the requirements of Section 703.3(D), Form 408. Commonwealth may require permittee to have material encountered in excavation tested for conformance to Section 703.3, Form 408.

          Prior to the replacement of the Base Course the existing Base and Surface must be sawed or drilled (holes six (6) inch on centers if drilled) one (1) foot on each side of the trench removed. The Base Course shall be replaced with a minimum of eight (8) inch High Early Strength Concrete to the elevation of the existing Crushed Area Base Course. The High Early Strength Concrete after placement must be cured in accordance with Section 704.1 (g), Form 408. Following the concrete curing a tack coat of bituminous material type E-1 will be required. The tack coat shall meet the requirements of Section 460, Form 408. After the tack coat has cured, the bituminous binder and/or wearing course shall be placed and should conform to the existing type of road binder and wearing courses.

          If the trench excavation exceeds four (4) feet in width, No. 6 reinforcing bars placed at six (6) inch center to center with a two (2) inch clear on each end and a three (3) inch clear on the bottom must be installed in the concrete base course.
        - b. Surface placed in excess of five (5) years prior to application for permit

          For projects involving utilities on State highways where the surface is in excess of five (5) years old, the base and surface restoration must be made as in Section 1.a. or as follows:

          The method of trench backfilling shall be in accordance with the requirements as set forth in Section 1a., Flexible Base Pavements.

Temporary restoration shall consist of a minimum eight (8) inch stone base with a two (2) inch bituminous material and shall be kept in place for a minimum of ninety (90) days.

The base course replacement shall consist of either a Crushed Aggregate Base Course (minimum of eight (8) inches of No. 4 aggregate tied in with No. 1 aggregate screenings meeting the requirements of Section 310, Form 408) or a Bituminous Concrete Base Course meeting the requirements of Section 305, Form 408. Minimum depth of Bituminous Concrete Base Course shall be five (5) inches. The binder and surface course shall be replaced in accordance with the depths of existing bituminous surface but in no case shall the binder course be less than one and one-half (1½) inch of 1D·2 and the wearing course be less than one (1) inch of 1D·2 or FJ·1. An additional one (1) foot on each side of the trench must be sawed or cut in a neat straight line prior to placing the bituminous surface material and Base Course as specified above.

2. Reinforced Cement Concrete Pavement –

If the existing pavement is a Reinforced Cement Concrete Pavement the method of trench backfilling shall be in accordance with the requirements as set forth in the preceding section for Flexible Base Pavement, Section 1a. The pavement shall be sawed or drilled in a neat straight line one (1) foot on each side of the trench prior to the replacement of the base.

The replacement base must consist of High Early Strength Concrete equal in depth of the original concrete pavement. The surface must be cured in accordance with Section 501.3(n) of the Form 408. After surface corrections have been completed and just before the concrete becomes non-plastic, the surface shall be given a textured finish in accordance with Section 501.3(m)4, Form 408.

3. Reinforced Cement Concrete Pavement –Bituminous Surface –

If the pavement structure is a reinforced Cement Concrete Pavement with a Bituminous Surface the method of trench backfilling and base and surface replacement shall be in accordance with the requirements as set forth for Flexible Base Pavement under Section 1a.

4. Pavements with Subbase –

If the work is to be performed on State highways with subbase as part of the pavement structure the trench shall be backfilled with twelve (12) inch of suitable material over the top of the utility and with No. 2 RC aggregate or suitable material meeting specifications for No. 2 RC minimum to within eight (8) inches of the subbase. An impervious material shall be then placed to the bottom of the existing subbase in four (4) inch compacted layers. The subbase shall be replaced to a height equal to the existing subbase. The subbase shall meet the requirements of Form 408. The base course and surface course shall then be placed in accordance to the previously specified instructions.

5. Utilities Utilizing the Shoulder of State Highways –
(Shoulder as defined in Form 408)

Backfilling and final restoration of the shoulder of State highways shall be made as follows:

Local material excavated from the trench may be used in backfill if the material complies with Pennsylvania Department of Transportation Specifications, Section 206.2, Form 408, and is mechanically compacted in four (4) inch layers to within eighteen (18) inches of final grade. The final eighteen (18) inches of backfill must be made with No. 2 RC aggregate or suitable material meeting specifications for No. 2 RC minimum mechanically compacted in four (4) inch layers. If the length of the utility exceeds fifty (50) feet, the shoulder must be graded, rolled and penetrated with RT-2C or RT-2W bituminous material at a rate of .25 or .30 gallon per square yard. If the disturbed or damaged shoulder is of a higher type than as specified above the work shall be reconstructed and restored in as firm, strong, and durable condition of the same type as before the commencement of work by permittee and/or its contractor, in accordance with the standards of the Commonwealth.

EXHIBIT 7

CITY OF TORONTO, ONTARIO

Cuts and Cut Repairs to Pavements, Sidewalks, Boulevards and Lanes

Cuts in the street pavement and sidewalks shall be carefully backfilled with granular "B" material and the material shall be compacted so as to secure not less than 95 percent of the maximum density of the material as determined by the modified Proctor Method in accordance with standard specifications. Excavated material, if suitable, can be used for backfilling purposes with the approval of the City Utility Inspector.

Sidewalk cuts which are not backfilled and surfaced with hot-mix asphalt shall be covered with plywood of adequate thickness and firmly secured for pedestrian traffic during non-working hours.

Every effort shall be made to tunnel or auger beneath private driveways and concrete walk approaches, but if broken out, permanent repairs shall be made to match existing conditions and to the satisfaction of the Commissioner of Public Works. Wherever possible, the entrance of services from the pavement to the sidewalk shall be made without breakage to the curb. Where the work is in the pavement, curb and sidewalk, the contractor shall carry out first-class temporary repairs in accordance with the standard requirements for underground construction.

The standard requirements for temporary repairs to pavements of streets and improved public lanes shall be: 2-inches of hot-mix asphaltic concrete on a base of 6-inch of crusher-run limestone. The base shall be well compacted to a level of 2 inches below the surface of adjacent paved area. All adjacent surfaces shall be painted with asphalt cement and a 2-inch cover of H.L. 3 asphaltic concrete shall be placed on the base. This surfacing shall be rolled or rammed so that it is tight and in uniform contact with all adjacent surfaces. (See Addendum)

The surface of the temporary repaving shall be smooth and at the same level as the adjacent undisturbed paved area. A seal of hot asphalt cement shall be poured along joints between the temporary repaving and the existing paved surface.

The standard requirements for temporary repairs to sidewalk shall be similar to those for travelled roadways, except that the limestone base course shall be omitted. The surface course shall be placed directly upon well-compacted backfill.

Where the work is in the boulevard, the surface whall be restored to its original condition. Also, cuts made within the limits of unimproved lanes shall be carefully backfilled, compacted and the surface restored to its original condition.

Trench cuts to the concrete pavements of public lanes shall, at the time of permanent repair, be overcut to the extent of 9 inches on either side of the original cut and the Applicant will be assessed the cost of repairs over the expanded width. Provision for poles and other surface installations to be centered on the curb line of monolithic concrete lane pavements, necessitating the removal of a portion of the curb, shall only be made by means of saw-cutting methods.

EXHIBIT 8

THE METROPOLITAN CORPORATION OF GREATER WINNIPEG, MANITOBA

17. Excavations Must be Properly Filled In.
    1. In every case of an excavation or opening in a pavement or sidewalk, and in all cases of tunneling, whether made by or on behalf of The Metropolitan Corporation of Greater Winnipeg or by or on behalf of any other person, in any street necessitating any backfilling or replacement of material, there shall be used only unshrinkable fill consisting of concrete mixed in the proportions of 50 pounds of Portland Cement to one cubic yard of concrete aggregate unless written permission is given by the Director to substitute for unshrinkable fill, in whole or in part, sand or gravel thoroughly tamped.
    2. All excavations in unpaved roadways shall be backfilled and the surface restored according to the following procedure:
        a. Mechanical Compaction or Water Tamping.
        Excavated material is to be replaced and consolidated by either mechanical compaction or water tamping as approved by the Director. The excavation is to be restored to grade using a final lift of crushed stone 6 inches in depth. Water tamping is defined as flushing of the backfilled excavation with water from a fire hose placed in 2-foot deep holes of diameter large enough to accept the hose, said holes to be at 20-foot intervals in the backfilled material. After flushing, the hole is brought to grade again and reflushed. The operation shall be repeated until no visible settlement appears.
        b. Granular Fill.
        Notwithstanding (a) granular fill shall be used when an excavation in an unpaved roadway is within 18 inches of the surface of the roadway. The gravel must be consolidated by water tamping or mechanical compaction. As an alternative to replacing the excavated material in an unpaved roadway where the excavation is greater than 18 inches in depth, well-graded ganular material may be placed and compacted and levelled off to meet the roadway surface.
    3. All excavations in boulevard areas shall be backfilled and the surface restored according to the following procedure:
        a. Mechanical Compaction.
        Excavated material to be replaced using maximum lifts of 1-foot thickness with each lift compacted by an approved mechanical compactor. The tamped backfill is to be brought to ground level.
        b. Granular Fill.
        As an alternative to mechanical compaction, the excavation may be filled with granular material placed, compacted and levelled off 18 inches below boulevard grade. Earth fill shall then be placed, tamped and levelled off to meet the boulevard surface.
    4. All work of filling or backfilling an excavation or opening or tunnelling, whether made by or on behalf of The Metropolitan Corporation of Greater Winnipeg or by or on behalf of any other person, in any street, and the method of filling and backfilling such openings, shall be subject to the inspection and approval and shall be done to the satisfaction of the Director.
    5. Where any excavation, opening or tunnelling is not backfilled immediately as provided in Subsection 2 and 3 of this section resulting in excessive costs to the Corporation for inspection of such excavation, the person making the excavation shall pay to the Corporation the cost of such additional inspection.
    6. In the event that any person fails to properly backfill an excavation or tunnel or opening or restore a boulevard cut as required by this by-law, the Corporation may perform such work as is deemed necessary by the Director, the cost of such work to be paid to the Corporation by the person making such excavation opening or tunnelling.
    7. Notwithstanding anything contained elsewhere herein the Director is hereby authorized to modify or vary any of the regulations contained in Subsection (1), (2), (3), and (4) of this section where such modification or variation in his opinion will substantially accomplish the object of the regulation. (AM B.L. 1698, Aug. 13/70).

APPENDIX D
NATIONAL CAPITAL COMMISSION INFORMATION SYSTEM

The National Capital Commission – a Canadian Federal agency, is responsible within the Ottawa/Hull Metropolitan Area, for the development of a computer based information system for use in regional and urban planning and management. The system has been developed by the Commission for its own use but will be made available to many other local agencies involved in planning, development and engineering. This system now has been leased after being under development for about four years. Substantial progress has been made and the pattern of future development is apparent.

In initiating this work the Commission decided that municipal and engineering data presented in the usual form of charts, tables and graphs would not suit its purposes and that an agency involved in planning and management of engineering services would need to establish direct relationships between the data which could be collected and actual cadastral survey. To do this, the geographical (X,Y) coordinates have been allocated to each individual property shown on the assessment rolls within the National Capital Region. Because the existing cadastral mapping is of high quality, this procedure has been reasonably easy to follow. The allocation of coordinates (digitizing) is carried out for the corners of each block, for the centers of each individual parcel and for property lines. (Within the National Capital Region, there are about 147,000 parcels and these are increasing at the rate of 750 per year.) As well, sufficient points are recorded so that the cadastral survey (a survey on such a scale that shows accurately the extent and measurement of every field and plot of land) of the block can be reproduced. A flat-bed plotter EAI 430/200 which has a plotting surface of 54 in. x 72 in. is used.

Data derived from the assessment rolls for each individual parcel is stored by using as an index the geographic coordinates of each parcel. However, this data can be retrieved by using coordinates, the street address, the name of the owner, tenant, or the assessment parcel number. Because the coordinates of all land holdings are plotted, information about streets, open space and vacant land is available. This method is equally useful in storing data about rural lands.

The assessment data is collected by other agencies and is recorded on magnetic tapes. Revised tapes are provided to the Commission annually, and the data is linked to (X,Y) coordinates using an index to match the assessment roll number. The newly assessed parcels are also mapped and digitized annually to assign geocoded centers. The data is returned to the assessment agencies with omissions and errors highlighted. The assessment data contains substantial amounts of census information such as age and structure of family units, which is invaluable for planning. Other sources provide other types of information which can be fed into the system by name, street address or coordinates. This may be welfare information, health statistics, traffic data, engineering information and the like. All this diverse information can be analyzed and plotted on cadastral maps.

To more fully use the capacity inherent in its system, the Commission has assisted in the development of procedures for deriving coordinates directly from aerial photographs by linking a digitizer to a typical stereo plotter. A normal topographic map carries about 35 types of information. These have been separated so that any individual function or group of functions can be plotted in any color at any scale between 1/1,250 and 1/12,500, including contours, buildings, streets, streams, vegetation, etc. This process is slightly more expensive than the usual method but avoids the high drafting costs involved in preparing the finished maps. Since the cadastral maps can be reproduced at the same range of scales, cadastral information can be plotted directly onto topographic maps and vice versa without using draftsmen. (In this connection, the draftsmen skilled in the preparation of plans and maps are needed to work closely with the E.D.P. staff).

Because of the ability to map data directly from the computer and to update the assessment data regularly (generally annually), the system serves the planning process requiring social, physical and economic data and also serves for the time series studies. A matter of interest to N.C.C. is migration by families within various sectors of the metropolitan area. By comparing the name of head of household or ages of family members where the names were identical on two successive assessment rolls, the Commission was able to map the movement of families in a city of 40,000 persons. Its findings correlated in number of movements with telephone company data.

The system can also be used to store and analyze engineering data required by the Commission and the municipalities. So far, engineering data is being stored only by its X and Y coordinates but it is expected that soon the vertical coordinate, probably height above Mean Sea Level in meters will also be stored. By so doing, programs for municipal services, utilities, etc., can be supplied with data directly from the disk storage and designs prepared. Given the X, Y, and Z coordinates, perspective drawings could be made which would show the actual services beneath the street level for use of contractors, etc. This is essentially the same procedure as that used in preparing architectural perspectives.

The computer capacity available in the system can be used for mathematical models to indicate future trends based on projection of existing data. Because an extensive amount of observed data on a time series basis is available, it is expected that trends can be more accurately extrapolated. A cathode ray tube (C.R.T.) is most effective in developing interactive graphic procedures. Already a C.R.T. is being used by the Commission to adjust adjacent maps, especially where rotation is involved.

The Commission believes that its geocoded centers of individual properties are particularly suitable to planning, engineering and management of urban regions because the method is flexible. The data, being in disaggregated form, permits comparing data of the future against data of the past. It is admitted that it takes time to set up the system but it appears to have unlimited possibilities for development. It could be used, for example, to store land records by a coordinate system.

Up to the present time and until the new computer has been installed, the actual computer work has been carried out by using terminals within the Commission connected to service bureau computers. This method has not been particularly satisfactory. Because of the large quantities of data, there are difficulties in mounting and handling disks effectively in a service bureau. When installed in late 1973, the accounting and financial activities of the Commission, covering some 1,200 employees, will be added to the present work load. However, the major applications are scientific rather than management oriented and are designed to support the planning and development process.

The leasing cost of the Honeywell 6000 computer with auto-trol digitizer and flat-bed plotter is approximately $20,000 per month.

APPENDIX E
TRAFFIC DELAY STUDIES

APWA undertook an extensive study to determine the amount of traffic delay which could be attributed to utility work within paved streets.

Before employing wide application of the data collection techniques, a *Procedural Manual for Field Tests* was drafted and a pilot study was conducted in Chicago, Illinois, to test the validity of the research approach. The manual was prepared to insure uniform collection of data among cooperating public agencies and was based on techniques commonly employed by such agencies in their regular traffic surveillance studies. The manual consisted of a description of steps to be taken in collecting and recording data and included both sample completed forms and blank forms.

Pilot Study

The City of Chicago agreed to participate in the pilot study by collecting the necessary field data for reduction and analysis by APWA research personnel. Special forms and instructional information were developed for the pilot study and later incorporated in the project's *Procedural Manual for Field Tests.*

City of Chicago traffic engineers selected a scheduled "spot" location construction site on Canal Street immediately south of Washington Street for the pilot study. Figure 16, Vicinity Map – Chicago, includes block lengths and the percent of green time (G/C ratio) for the fixed time traffic signals. Construction was performed by city crews and involved the replacement of an 18-inch diameter combined sanitary sewer-storm drain.

Canal Street at this location is a one-way northbound street, 60 feet in width between curbs, providing four 11-foot travel lanes and parallel parking on both sides under normal conditions. (Normal conditions, as used in these studies, refers to conditions which occurred either before and/or after the construction activity took place.) Figure 17 is "Before" and "During" Pavement Marking Conditions, and Figure 18 is Permanent Signing Conditions. Figure 19, Pilot Test Site, contains photographs indicating the congestion during construction.

The adjacent land use is commercial with large office buildings located on the east side of Canal Street and the Northwestern Railroad Station on the west side. The work area was protected by barricades but traffic cones and advance warning signs were not utilized for controlling traffic flow.

In addition to on-road construction vehicles, a backhoe, crane and compressor were the larger types of equipment used during construction. The trench located within the barricaded work area was eight feet in width, 35 feet in length and 20 feet in depth.

The construction permit required that traffic be maintained at all times. Parking was restricted by signs on the east side and the area was utilized by moving vehicles except during the morning hours when the far right (east) curb lane was used by construction trucks for temporary parking and intermittently throughout the study by

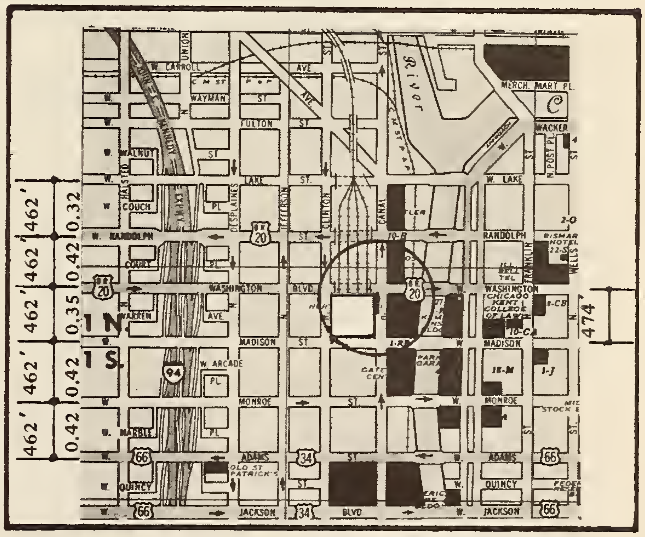
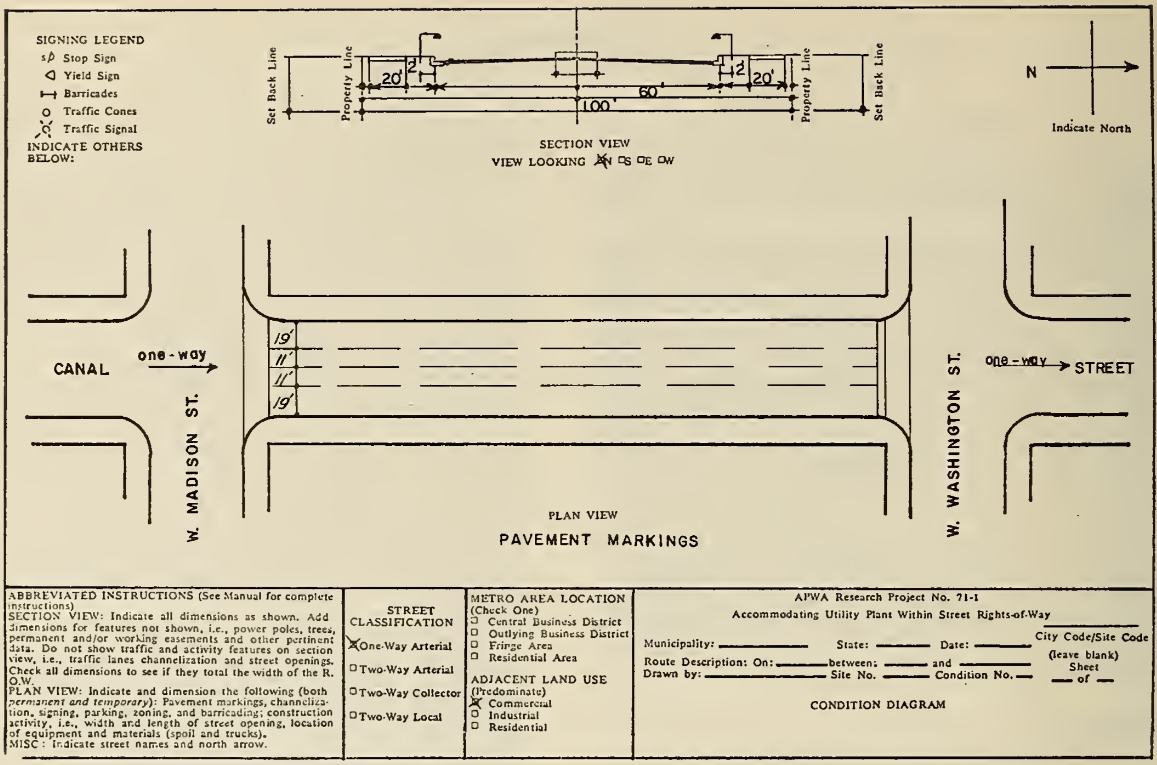


FIGURE 16 VICINITY MAP – CHICAGO
(Westerly portion of the Central Business District showing location of pilot study, dimensions of Canal Street between cross street centerlines and percent green time of fixed time 20 signals)



ABBREVIATED INSTRUCTIONS (See Manual for complete instructions)
SECTION VIEW: Indicate all dimensions as shown. Add dimensions for features not shown, i.e., power poles, trees, permanent and/or working easements and other pertinent data. Do not show traffic and activity features on section view, i.e., traffic lanes channelization and street openings. Check all dimensions to see if they total the width of the R.O.W.
PLAN VIEW: Indicate and dimension the following (both *permanent and temporary*): Pavement markings, channelization, signing, parking, zoning, and barricading; construction activity, i.e., width and length of street opening, location of equipment and materials (spoil and trucks).
MISC: Indicate street names and north arrow.

STREET CLASSIFICATION
☒ One-Way Arterial
☐ Two-Way Arterial
☐ Two-Way Collector
☐ Two-Way Local

METRO AREA LOCATION (Check One)
☐ Central Business District
☐ Outlying Business District
☐ Fringe Area
☐ Residential Area

ADJACENT LAND USE (Predominate)
☒ Commercial
☐ Industrial
☐ Residential

APWA Research Project No. 71-1
Accommodating Utility Plant Within Street Rights-of-Way

Municipality: ______ State: ______ Date: ______
Route Description: On: ______ between: ______ and ______
Drawn by: ______ Site No. ______ Condition No. ______
City Code/Site Code (leave blank)
Sheet ___ of ___

CONDITION DIAGRAM

FIGURE 17 "BEFORE" AND "DURING" PAVEMENT MARKING CONDITIONS, (Chicago, Canal Street between W. Madison and W. Washington Streets)

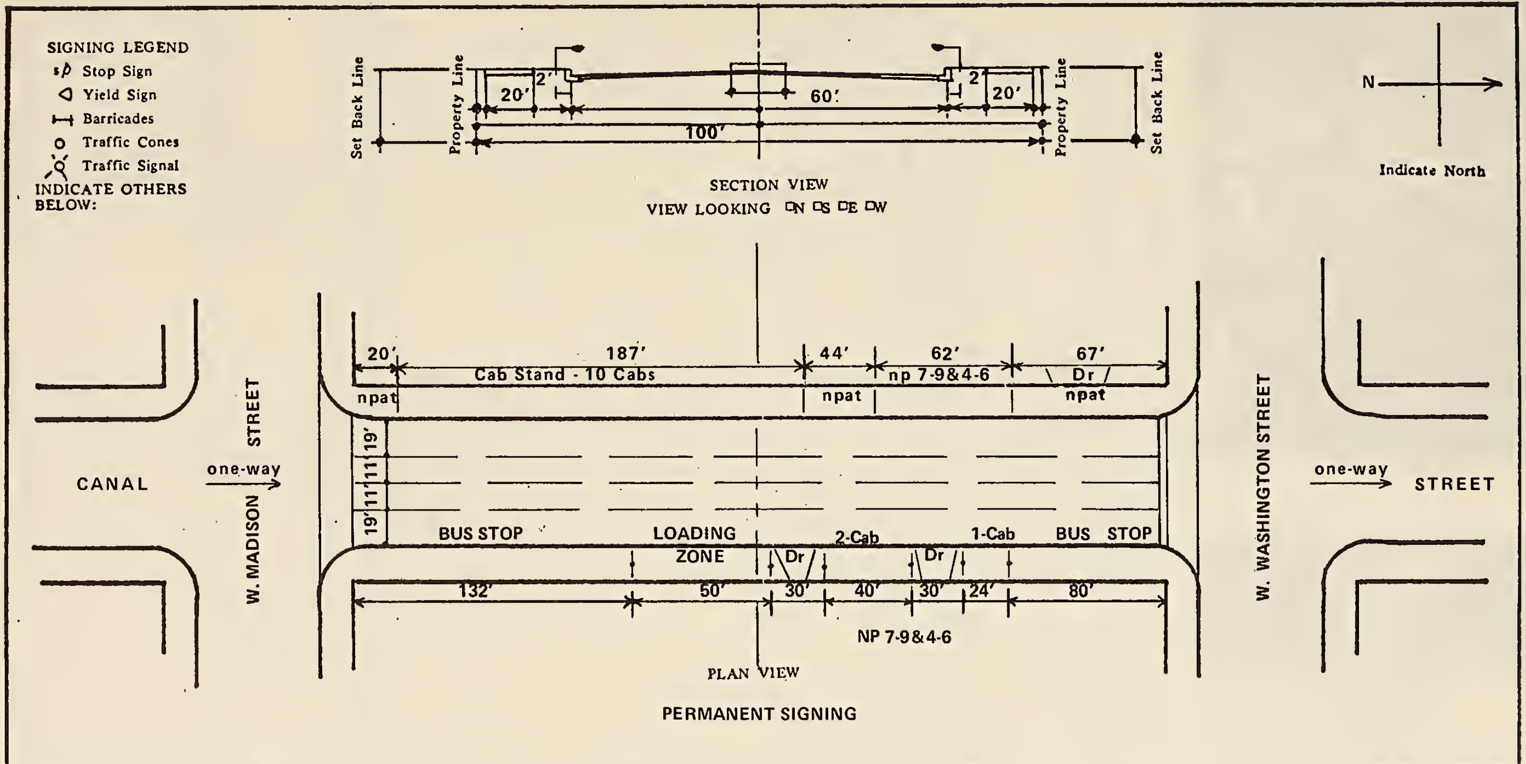
transit vehicles loading and unloading passengers. Construction crews arrived at approximately 8:45 a.m.

Site conditions found for the morning study period appear in Figure 20, "During" Conditions for the Morning Study Period. Conditions found for the noon and afternoon study periods appear in Figure 21, "During" Conditions for the Noon and Afternoon Study Periods.

A summary of the data collected by observers in the test vehicle under "before" (normal) and "during" (activity) conditions is shown in Table 20, Average Overall Travel Times and Delay on Canal Street – by Study Periods and Times on Canal Street in Chicago, Illinois, and stop delay time is shown in Table 21, Stop Delay Time at Construction Site and Intersection – Downstream from Construction Site on Canal Street in Chicago, Illinois, and Table 22, Stop Delay Time at All Intersections on Overall Route and at Construction Site – Canal Street in Chicago, Illinois. The short section was 474 feet in length. Average overall travel time for the short section included running and stop time at the downstream traffic signal (W. Washington Street); running and stop time related to the construction activity and other frictional effects. No stop time was attributed to flagmen in either the long or short section runs.

Travel-time data collected during the morning period was considered invalid since barricades were relocated on several occasions resulting in a change in the number of travel lanes utilized and construction vehicles parked on occasion in the far right curb lane.

A 24-hour mechanical traffic count taken under normal conditions (beginning at 8:00 a.m. Thursday, November 2, 1972, and ending at 8:00 a.m. Friday, November 3, 1972) recorded 11,588 vehicles. However, the pneumatic road tube was displaced between



ABBREVIATED INSTRUCTIONS (See Manual for complete instructions)
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PLAN VIEW: Indicate and dimension the following (both *permanent and temporary*): Pavement markings, channelization, signing, parking, zoning, and barricading; construction activity, i.e., width and length of street opening, location of equipment and materials (spoil and trucks).
MISC: Indicate street names and north arrow.

STREET CLASSIFICATION
- ☒ One-Way Arterial
- ☐ Two-Way Arterial
- ☐ Two-Way Collector
- ☐ Two-Way Local

METRO AREA LOCATION (Check One)
- ☒ Central Business District
- ☐ Outlying Business District
- ☐ Fringe Area
- ☐ Residential Area

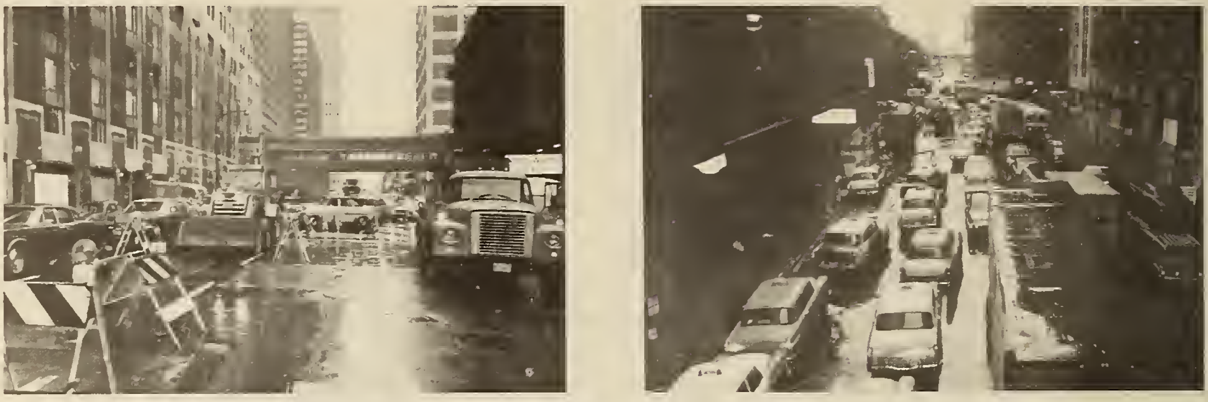
ADJACENT LAND USE (Predominate)
- ☐ Commercial
- ☐ Industrial
- ☐ Residential

APWA Research Project No. 71-1
Accommodating Utility Plant Within Street Rights-of-Way

Municipality: ______ State: ______ Date: ______ City Code/Site Code (leave blank)
Route Descriptions On: ______ between: ______ and ______ Sheet
Drawn by: ______ Site No. ______ Condition No. ______ __ of __

CONDITION DIAGRAM

FIGURE 18 PERMANENT SIGNING CONDITIONS



These photographs show the location of the activity and traffic congestion during construction.

FIGURE 19 PILOT TEST SITE

TABLE 20
AVERAGE OVERALL TRAVEL TIMES AND DELAY ON CANAL STREET – BY STUDY PERIODS AND TIMES ON CANAL STREET IN CHICAGO, ILLINOIS

STARTING TIMES First & Last Runs	AVERAGE OVERALL TRAVEL TIMES, SEC. (including stop time) BEFORE			DURING			AVERAGE OVERALL DELAY, SEC.[1]		AVERAGE NUMBER VEH./15-Min.
	No. Runs	Section Long	Section Short	No. Runs	Section Long	Section Short	Section Long	Section Short	"Before"[2]
Morning Peak									
7:30 – 8:45 a.m.	6	125.1	18.2	6	149.5[3]	69.7[3]	24.4	51.5	239
Noon Peak									
12:00 – 1:15 p.m.	6	90.0	21.5	6	120.3	25.3	30.3	3.8	194
Afternoon Peak									
4:30 – 5:45 p.m.	6	187.5	28.1	6	811.0	175.3	623.5	147.2	228

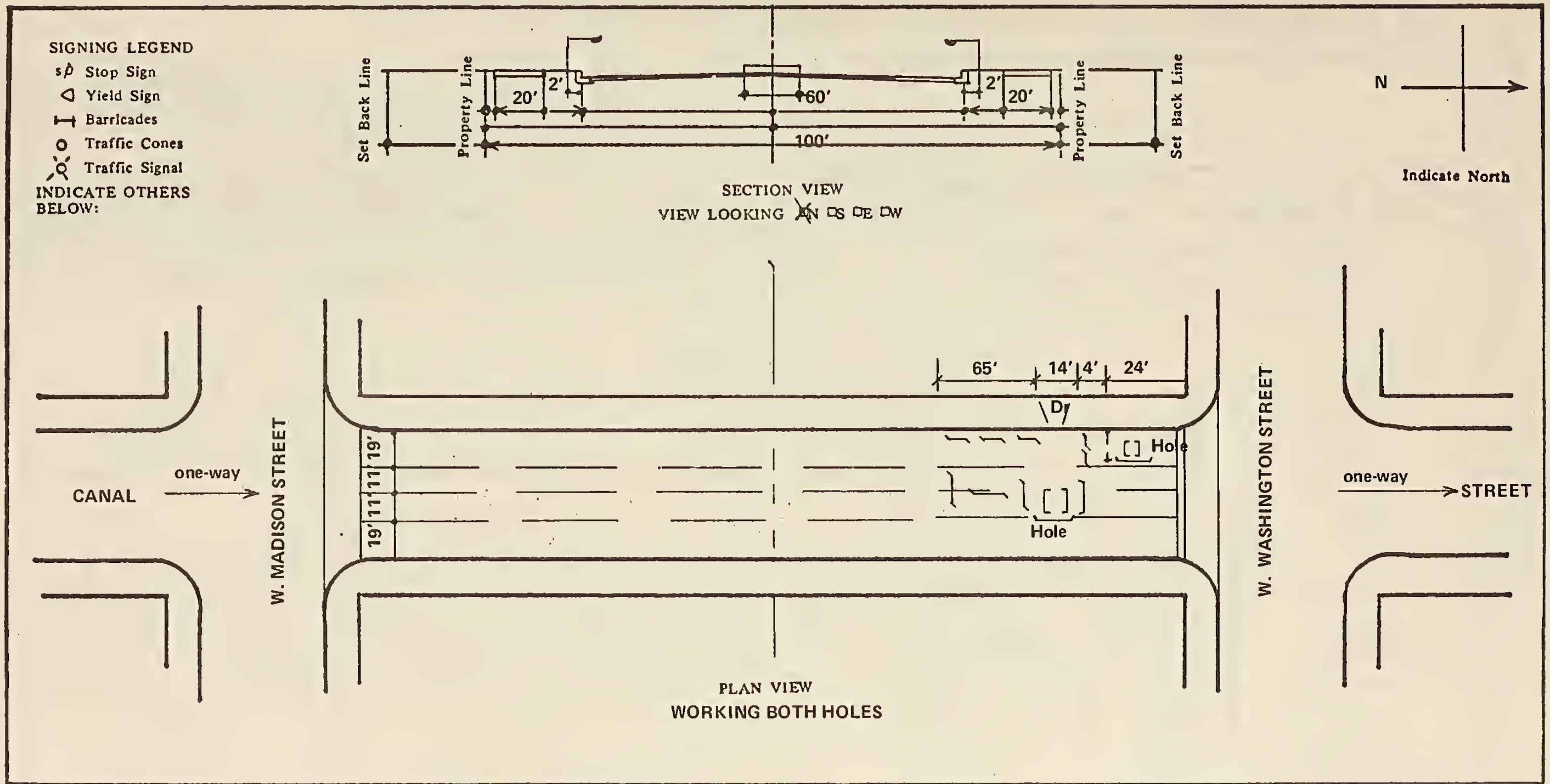
[1] Difference between "Before" and "During" Average Overall Times

[2] "During" traffic volumes not available

[3] Recorded immediately prior to construction activity taking place

TABLE 21
STOP DELAY TIME AT CONSTRUCTION SITE AND INTERSECTION – DOWNSTREAM FROM CONSTRUCTION SITE ON CANAL STREET IN CHICAGO, ILLINOIS

STARTING TIMES First & Last Runs	BEFORE No. Stops	Time, Sec. Total	Time, Sec. Average	Primary Cause	DURING No. Stops	Time, Sec. Total	Time, Sec. Average	Primary Cause	Secondary Cause
Morning Peak									
7:30 – 8:45 a.m.	1	10.0	10.0	sig. only	4	177.0	44.2	signal	activity
Noon Peak									
12:00 – 1:15 p.m.	5	28.0	5.6	sig. only	3	99.0	33.0	signal	activity
Afternoon Peak	1	40.0	40.0	sig. only	3	539.0	179.0	activity	none



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PLAN VIEW: Indicate and dimension the following (both *permanent and temporary*): Pavement markings, channelization, signing, parking, zoning, and barricading; construction activity, i.e., width and length of street opening, location of equipment and materials (spoil and trucks).
MISC: Indicate street names and north arrow.

STREET CLASSIFICATION
☒ One-Way Arterial
☐ Two-Way Arterial
☐ Two-Way Collector
☐ Two-Way Local

METRO AREA LOCATION (Check One)
☒ Central Business District
☐ Outlying Business District
☐ Fringe Area
☐ Residential Area

ADJACENT LAND USE (Predominate)
☒ Commercial
☐ Industrial
☐ Residential

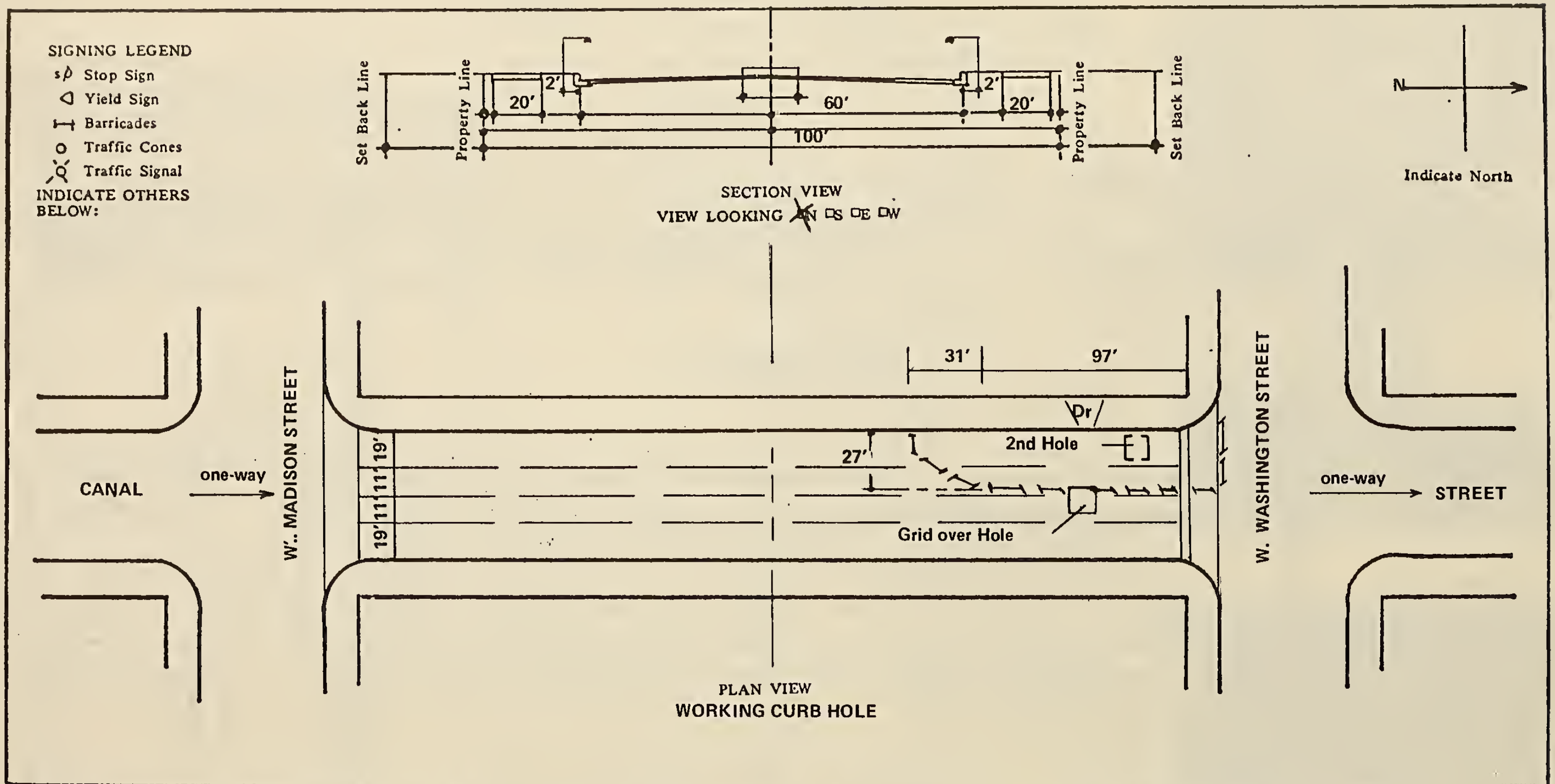
APWA Research Project No. 71-1
Accommodating Utility Plant Within Street Rights-of-Way

Municipality: ______ State: ______ Date: ______
Route Descriptions On: ______ between: ______ and ______
Drawn by: ______ Site No. ______ Condition No. ______

City Code/Site Code
(leave blank)
Sheet
___ of ___

CONDITION DIAGRAM

FIGURE 20 "DURING" CONDITIONS FOR THE MORNING STUDY PERIOD
(Location of work area and site.)



ABBREVIATED INSTRUCTIONS (See Manual for complete instructions)
SECTION VIEW: Indicate all dimensions as shown. Add dimensions for features not shown, i.e., power poles, trees, permanent and/or working easements and other pertinent data. Do not show traffic and activity features on section view, i.e., traffic lanes channelization and street openings. Check all dimensions to see if they total the width of the R. O.W.
PLAN VIEW: Indicate and dimension the following (both *permanent and temporary*): Pavement markings, channelization, signing, parking, zoning, and barricading; construction activity, i.e., width and length of street opening, location of equipment and materials (spoil and trucks).
MISC: Indicate street names and north arrow.

STREET CLASSIFICATION
☒ One-Way Arterial
☐ Two-Way Arterial
☐ Two-Way Collector
☐ Two-Way Local

METRO AREA LOCATION
(Check One)
☒ Central Business District
☐ Outlying Business District
☐ Fringe Area
☐ Residential Area

ADJACENT LAND USE
(Predominate)
☒ Commercial
☐ Industrial
☐ Residential

APWA Research Project No. 71-1
Accommodating Utility Plant Within Street Rights-of-Way

Municipality: ______ State: ______ Date: ______
Route Descriptions On: ______ between: ______ and ______
Drawn by: ______ Site No. ______ Condition No. ______
City Code/Site Code
(leave blank)
Sheet ___ of ___

CONDITION DIAGRAM

FIGURE 21 "DURING" CONDITIONS FOR THE NOON AND AFTERNOON STUDY PERIODS
(Location of work area and site.)

TABLE 22
STOP DELAY TIME AT ALL INTERSECTIONS ON OVERALL ROUTE AND AT CONSTRUCTION SITE – CANAL STREET IN CHICAGO, ILLINOIS

Starting Times of First and	BEFORE				DURING				
First & Last Runs	No. Stops	Time, Sec. Total	Time, Sec. Average	Primary Cause	No. Stops	Time, Sec. Total	Time, Sec. Average	Primary Cause	Secondary Cause
Morning Peak									
7:30 – 8:45 a.m.	10	199.0	19.0	sig. only	11	375.0	34.1	signal	activity
Noon Peak									
12:00 – 1:15 p.m.	8	50.0	6.2	sig. only	5	185.0	37.0	signal	activity
Afternoon Peak									
4:30 – 5:45 p.m.	10	435.0	43.5	sig. only	13	2,085.0	160.4	activity	signal

12:30 and 1:15 p.m.; therefore, for the purposes of this study, the count was increased to 12,000 by a factor based on interpolation of available data. Traffic counts were not collected *during* the study period. Since traffic counts were not recorded during the construction activity when travel times were measured between 12:00 and 1:15 p.m., the noon study was not considered as reliable as the afternoon study when *like* fixed (construction) conditions remained constant and traffic counts were available for comparative purposes.

Although the number of test vehicle runs, particularly under obstructed conditions during the afternoon period, were limited and might be subject to question from a statistical viewpoint, the great difference in average overall travel time between the "before" and "during" periods (147 vehicle seconds of delay for the short section) and consistency within each period was considered to be very significant. Adding to the significance of this delay is the fact that the test vehicle was only required to make one stop for a total of 40 seconds under normal ("before") conditions which was caused by the immediate downstream traffic signal. This is contrasted by the "during" (obstructed conditions) period when the test vehicle was required to make three construction-related stops for an average of 179 seconds. In addition, it should be noted that the test vehicle in the latter case was not required to stop at the immediate downstream traffic signal (W. Washington Street). If more test runs had been conducted "during" the activity period, it is highly probable that stops would have been made at the traffic signal, thus adding greatly to the delay indirectly attributed to the utility project.

Field observations indicated that delay might have been reduced if travel lanes had been delineated by the use of traffic cones or similar control devices.

As previously mentioned, one of the purposes of the pilot study was to determine the cooperating public agency study team's attention to instructions described in the draft of the procedural manual. Human errors observed in the pilot study were noted and the draft manual was edited to bring attention to its apparent shortcomings which included the necessity of conducting traffic counts "during" the construction activity and providing more detail in the recording of significant events in the "Activity Log."

Study Areas

The fifteen local public agencies which collected the necessary data at 38 sites for reduction and analysis by APWA research personnel are listed in Table 23, Cooperating Local Public Agencies Involved in Data Collection.

Data Collection and Reduction

This section describes the steps taken in the collection of field data by cooperating public agencies and reduction of that data for purposes of analysis by APWA research personnel.

TABLE 23
COOPERATING LOCAL PUBLIC AGENCIES INVOLVED IN DATA COLLECTION

Atlanta, Ga.	Minneapolis, Minn.
Baltimore, Md.	Montreal, Que.
Baton Rouge, La.	Oakland, Calif.
Chicago, Ill.	Phoenix, Ariz.
Columbus, Oh.	San Diego, Calif.
Des Moines, Ia.	Seattle, Wash.
Greensboro, N.C.	Wichita, Kan.
Jacksonville, Fla.	

Utility construction and maintenance activities can take place during any time of the day, week, month or year and at a variety of locations within the public street rights-of-way. They involve working underground and overhead within and adjacent to the roadway. However, it is the work within the roadway, particularly in the traveled portion, which has the greatest effect on traffic flow. This is especially true at intersecting streets where the activity affects a multitude of vehicular movements. These conditions can be found on all types of streets and in all locations of the urban area, ranging from low-volume, low-speed local streets in residential areas to high-volume, high-speed arterials in densely developed business districts.

Recognizing the wide array of fixed conditions and many traffic variables to be found in urban areas, it was determined that a representative sample of as many of the significant situations normally encountered should be collected. This decision led to the development of a list of independent variables deemed desirable for study. These characteristics are listed in the cards shown in Figure 22, Independent Variable Measured at Each Study Site Categorized for Evaluation. Card No. 1 contains community and street data under normal conditions; Card No. 2 contains the work area and traffic channelization data during construction; and Card No. 3 contains travel time and delay data.

To hold the number of independent variables to a reasonable level, the following fixed conditions were stipulated for all proposed study sites:

- All roadways should be paved, with curbs, and in good riding condition. This constraint was considered reasonable since the greatest mileage of urban streets with notable traffic volumes fits this condition.
- Horizontal curves should be avoided if at all possible and grades in excess of five percent should also be avoided.
- Only four-way, right-angle intersections should be studied. No restrictions should be placed on types of traffic control devices, e.g., traffic signal, stop sign, channelization, etc.
- Complete closure of study routes should be avoided.
- Sites with unusually large percentages of buses and trucks should be avoided.

Other aspects of the "parent" research project revealed a greater number of utility-related activities take place at nonintersectional locations than at locations within intersections. It is generally agreed, however, that the impact of such activities on the flow of traffic is greater at intersectional locations. Therefore, in order to obtain a reasonable sample, an attempt was made to collect data at six intersections and 18 nonintersectional locations. Of the six desired intersectional types, two were to be signalized and located in the central business district (CBD), two were to be signalized non-CBD intersections and two were to be unsignalized intersections in locations outside the CBD. The agencies were given a choice of studying utility activities taking place either near the center of those intersections or near a curb in the intersection. Desired ranges of average daily traffic (ADT) were also provided. No restriction was placed on street types (e.g., arterial), or direction of flow (e.g., one-way streets or two-way streets involving centerline street crossovers). Ranges for roadway width and number of travel and parking lanes were specified. Desired study parameters are listed in the Procedural Manual.

APWA FIELD TEST DATA
EFFECT OF LANE CLOSURES ON TRAFFIC
CARD NO. 1 - COMMUNITY AND STREET DATA - NORMAL

MUNICIPALITY NAME		COMMUNITY DATA			SITE DATA				STREET AND NORMAL TRAFFIC DATA CONDITIONS																			DISTANCE BETWEEN REFERENCE POINTS											
											PAVEMENT WIDTH			TRAFFIC LANES			PARKING LANES								TRAFFIC CONTROLS					WORK AREA BLOCK								
	TEST NUMBER	CITY NUMBER	STATE NUMBER	METROPOLITAN STATUS CODE	POPULATION CATEGORY	TYPE	LOCATION	LAND USE DISTRICT	ADT CATEGORY	% TRUCKS CATEGORY	STREET TYPE CODE	PRIMARY DIRECTION	OPPOSING DIRECTION	TOTAL	PRIMARY DIRECTION	OPPOSING DIRECTION	TOTAL	PRIMARY DIRECTION	OPPOSING DIRECTION	TOTAL	MEDIAN WIDTH	RIGHT OF WAY WIDTH	CURB CODE	SIDEWALK CODE	BLOCK LENGTH	INTERSECTION AHEAD	INTERSECTION BEYOND	A 4TH INTERSEC. PRECEED. WK	B 3RD INTERSEC PRECEED. WK	C 2ND INTERSEC PRECEED. WK	D 1ST INTERSEC PRECEED. WK E BEGIN TAPER	F BEGIN MIN. ROAD WIDTH	G END MIN. ROAD WIDTH	H END TAPER	I 1ST INTERSEC BEYOND WORK	J 2ND INTERSEC BEYOND WORK	K 3RD INTERSEC BEYOND WORK	L 4TH INTERSEC BEYOND WORK	CARD NO. 1
																												A-B	B-C	C-D	D-E	E-F	F-G	G-H	H-I	I-J	J-K	K-L	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	

a. Card No. 1 – Community and Street Data – Normal

FIGURE 22 INDEPENDENT VARIABLES MEASURED AT EACH STUDY SITE CATEGORIZED FOR EVALUATION

APWA FIELD TEST DATA
EFFECT OF LANE CLOSURES ON TRAFFIC
CARD NO. 2 - WORK AREA AND TRAFFIC CHANNELIZATION DATA DURING OBSTRUCTION

0 1 2 3 4 5 6 7 8

1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0

MUNICIPALITY NAME	TEST NUMBER	WORK AREA AND TRAFFIC CHANNELIZATION DATA DURING OBSTRUCTION																																												CARD NO. 2
		Location of Obstruction Code	WIDTH OF WORK AREA			WIDTH OF AVAILABLE ROADWAYS AS CHANNELED								Did Traffic Cross Centerline? (Check)	Lanes used alternately in both dir.?	LANES OF TRAFFIC MAINTAINED								LONGITUDINAL DATA IN WORK AREA BLOCK										TYPE AND CONDITIONS OF THE WORK												
						In Primary Roadway			In Opposing Roadway				Total Width Available-Both Roadways			In Prim. Road		In Oppos. Road			In Both Roads			IN PRIMARY ROADWAY					IN OPPOSING ROADWAY																	
			In Primary Roadway	In Opposing Roadway	Total Width in Roadway	To Right of Obstruction	To Left of Obstruction	Total Width Available	For Exclusive Use In Primary Dir. (Crossover)	For Exclusive Use In Opposing Direction	For Alternate Use By Both Directions	Total Width Available				Prin.Dir.-Right of Obs.	Prin.Dir.-Left of Obs.	Excl.in Prin.Dir.(C.O.)	Excl.in Opposing Dir.	Altern.by both dir.	Tot.-Excl.use Prim.Dir.	Tot.-Excl.use Oppo.Dir.	Total Lanes Used	LENGTH OF WORK AREA	LENGTH OF TAPER	TAPER RATIO LONG. TO 1 TRANSVERSE	DISTANCE-AHEAD OF WORK AREA	DISTANCE-BEYOND WORK AREA	LENGTH OF WORK AREA	LENGTH OF TAPER	TAPER RATIO LONG. TO 1 TRANSVERSE	DISTANCE-AHEAD OF WORK AREA	DISTANCE-BEYOND WORK AREA	Parking Res. During Wk?	Traf. Signals Adjusted?	Flagmen Used?	Pavement Excavated?	DURATION OF OBSTRUCTION DAYS — HOURS	Part of Larger Job	Direction of the Work	Type of Job	UTILITY TYPE	Class of Utility	Scheduled or Emergency?		
	1	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81		

b. Card No. 2 – Work Area and Traffic Channelization Data During Construction

FIGURE 22 INDEPENDENT VARIABLES MEASURED AT EACH STUDY SITE CATEGORIZED FOR EVALUATION

APWA FIELD TEST DATA
EFFECT OF LANE CLOSURES ON TRAFFIC
CARD NO. 3 - TRAVEL TIME AND DELAY DATA

0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8
1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0

TRAVEL TIME AND DELAY DATA

WORK AREA (D – I)
BLOCK (F – G)

A 4TH INTER. PREC. WORK
B 3RD INTER. PREC. WORK
C 2ND INTER. PREC. WORK
D 1ST INTER. PREC. WORK
E BEGIN TAPER
F BEGIN MIN. ROAD WIDTH
G END MIN. ROAD WIDTH
H END TAPER
I 1ST INTER. BEYOND WORK
J 2ND INTER. BEYOND WORK
K 3RD INTER. BEYOND WORK
L 4TH INTER. BEYOND WORK

MUNICIPALITY NAME		RUN CODE			DATE				WEATHER AND PAVEMENT COND.				TIME AT START OF RUN					Traffic Queues		TRAVEL TIME BETWEEN REFERENCE POINTS (SEC)														STOPS		CARD NOS. 3 THRU
	TEST NUMBER	Case:1-Bef.2-Dur.3-Aft.	RUN NUMBER	Dir.1-Primary,2-Opposing	Day of Week	Month	Day	Year	Weather	TEMPERATURE - °F	Pavement Condition	Riding Quality	Traffic Period	HOUR	MINUTE	AM - PM	15 MINUTE TRAFFIC VOLUME	Blocks in Primary Dir.	Blocks in Opposing Dir.	A-B	B-C	C-D	D-E	E-F	F-G	G-H	H-I	I-J	J-K	K-L	TOTAL TRAVEL TIME	TOTAL DIST. (ft.)	AVE. SPEED ft/sec	NUMBER	TOTAL SECONDS	
	1	82	83	84	85		86		87	88	89	90	91	92			93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	

c. Card No. 3 – Travel Time and Delay Data

FIGURE 22 INDEPENDENT VARIABLES MEASURED AT EACH STUDY SITE CATEGORIZED FOR EVALUATION

To meet project deadlines, it was necessary that the studies be conducted during three winter months. As contrasted with warmer summer months, relatively few construction-maintenance activities are programmed during winter months. This is particularly true of utilities located in the snowbelt. Therefore, it was difficult for some public agencies to locate *scheduled* utility activities which met the study parameters. In other cases, the "normal" studies took place after the construction or maintenance activity was completed. This did, however, provide the advantage of better coordination of starting times for the travel time studies. Since all desired sites meeting the required parameters were *not* found, some agencies were asked to provide studies at sites similar to those studied by other agencies.

Interpretation and Appraisal

The ultimate goal of this aspect of the research project was to determine the degree of motorist and vehicle costs associated with utility construction and maintenance activities. Once these costs were determined they would be evaluated with costs associated with other utility-related activities and serve as a significant element in arriving at optimum locations for utilities within the public rights-of-way.

One of the primary objectives of this goal was to develop a mathematical function relating average overall delay (attributed directly or indirectly to utility activities) to site and traffic characteristics.

It was concluded that if a mathematical function could be developed for the effect of utility-related activities in complex urban conditions, it would be used to determine best horizontal (longitudinal and transverse) utility locations. It would also be of benefit to traffic engineers in determining "best" times (situations) for allowing scheduled utility activities to be performed.

Based on probability distributions, the aggregate behavior of drivers can be predicted under various given conditions but not precisely reproduced. This becomes more difficult to accomplish as the environment becomes more complex, e.g., residential to business. Such is the case of traffic flow which is interrupted by traffic signals, parking maneuvers, drastic changes in lane widths, *construction* activities and numerous other fixed and movable impediments.

Previous studies, as reported in the *Highway Capacity Manual* (pp. 67-72), have found that the relationship between flow and density is curvilinear, as shown in Figure 8, Example of Flow-Density Relationship in Limited-Access Traffic Flow. Density is the number of vehicles in a particular length of roadway at a particular moment. This differs from flow, which is a rate of movement per unit of time. The Manual also reports a study which found a straight-line speed-density relationship. It is generally recognized then that as density increases, speed decreases up to the point of critical density. Beyond that point, however, a decrease in flow can be expected even though there is a continued increase in density. The *point* of critical density is difficult to estimate under interrupted flows found in urban areas. Generally, signalized intersections are considered as the primary variable affecting urban arterial capabilities. However, because of numerous nonintersectional impediments, the *Manual* recognized the impracticability of determining relationships among speed, volume, and density for "downtown" streets and the difficulty of doing such on arterial streets. Thus, no recognized procedures have been developed for determining the *point* of

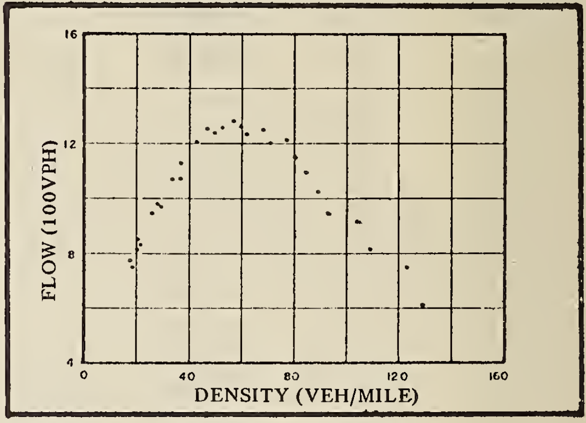


FIGURE 23 EXAMPLE OF FLOW-DENSITY RELATIONSHIP IN LIMITED-ACCESS TRAFFIC FLOW (HOLLAND TUNNEL, NEW YORK).

critical density. Simply stated, good judgment would dictate that unless the addition of utility activity were the "primary contributing" cause for density reaching its critical point, it could be reasoned that no restraints should be placed on the activity, save those for protection of the work site, other property and the traveling public. In other words, if it could be predetermined that the activity would be "the straw that would break the camel's back" it should not be allowed to occur under such conditions.

Recognizing that the majority of existing utilities will not be relocated from or within the rights-of-way, particularly the travel portion, it then becomes necessary that nonemergency activities take place only during noncritical (traffic) times. Many public agencies have "blanket" policies which prohibit nonemergency activities during peak periods on all streets. In other cases such policies may be restricted only to a particular street classification, such as arterials. If the capacity under such conditions exceeds demand, no significant problem should be expected and good judgment would question the equity of such "no-peak-period-work" policies. This is particularly true in light of the large percent of urban street mileage which has an excess of capacity. The alternate to "blanket" policies is either good judgment on the part of the responsible public official – which, for the most part, must be based on the "fly-by-the-seat-of-the-pants" approach – or developing a method by which critical situations could be predetermined.

Since the point of critical density cannot be calculated at nonintersectional locations with the desired degree of reliability necessary for purposes of this project, it was determined that measurements would be made in the real-life environment to serve as the basis for developing a mathematical function.

In the *ideal* scientific situation, potentially important (independent) factors for the study situation (dependent factor) are listed. A study design is developed, controls are placed on the levels of the independent factors and observations are made of the dependent factor for each combination. If properly conducted, such an experiment usually produces a good mathematical relation among the factors. There are three primary reasons why this procedure usually works: (1) the design of the experiment explores the important combinations of the independent factors; (2) the design produces data in a way that explains the effect of each independent factor by itself; (3) randomization of experimental units protects against the possibility of disaster from unknown factors.

An example of the ideal procedure as it might apply to this project follows: The first step involves listing the most important factors affecting motorist delay, such as street type, traffic volumes, available roadway width, etc. For each factor, the number of levels to be explored must be specified. For purposes of this example, assume there are five street types (A, B, C, D and E); two conditions of roadway width, a one-lane width (narrow) and a three-lane width (wide); and two traffic volumes (small and large). Referring to Table 24, Example of Independent Factors by Degree, assume the five street types are known. For each street type, a narrow and a wide width must be specified; thus, resulting in 10 combinations of street types and widths. For each of these 10 combinations, a low and a high-traffic volume are specified for a total of 20 combinations. It may be that traffic-volume criteria is independent of the available roadway width (lanes). In the ideal experiment, randomization would occur. For example, from all type A streets with low-traffic volume, a small obstruction would be selected and imposed at random. We had no such control in this experiment, since the ideal scientific situation is not typical of the real-life environment.

TABLE 24
EXAMPLE OF INDEPENDENT FACTORS BY DEGREE

	One Lane		Three Lane	
Street Type	Low Traf. Volume	High Traf. Volume	Low Traf. Volume	High Traf. Volume
A				
B				
C				
D				
E				

Evaluation of Flow Data

• *Collective Statistical Evaluation.* The first stage in the analysis phase of the study attempted to determine a relationship between average overall delay and traffic volume in terms of vehicles per hour per approach to the activity site using the following equation:

$$\text{Delay} = (\text{volume})^k$$

where *A* varies from site to site and *k* is constant across sites. This equation estimated the value of the parameter *A* for each site approach. Values of *A* are then related to various site characteristics on cards one and two (see Table 6) using regression analysis. The regression analysis would attempt to show:

$$A = f(x_1, s_2, \ldots, x_n)$$

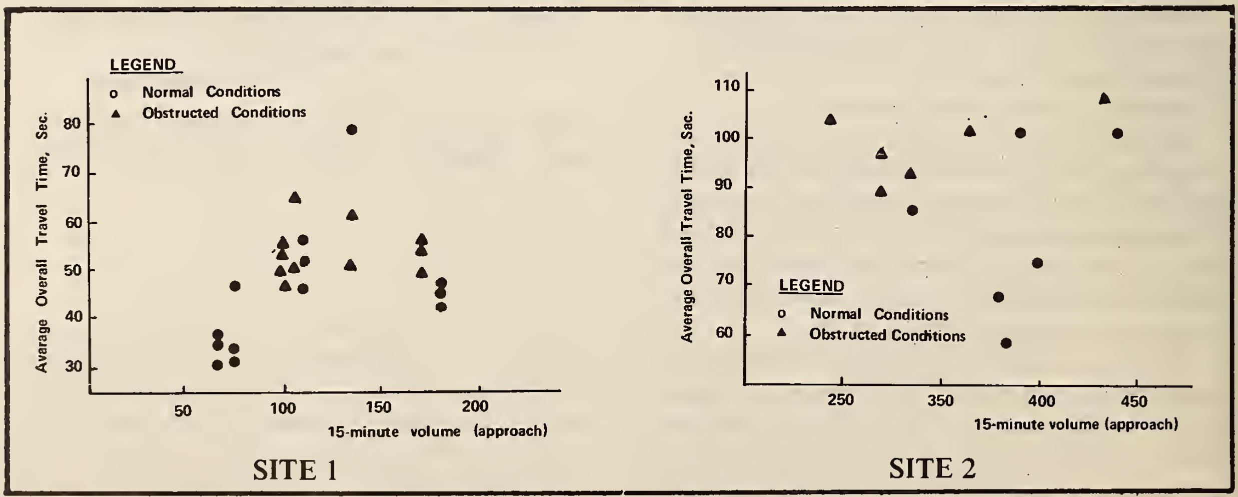
where the x_1's are the site variables. If meaningful and significant functions emerge, average overall delay could be estimated for sites having similar variables.

Using the above equations, attempts were made to relate delay to site characteristics of nonintersectional locations categorized by *short* or immediate sections (normally one block in length) and *long* sections (normally four to six blocks in length).

Travel times recorded for each test-vehicle run and corresponding 15-minute approach volumes recorded under normal and obstructed conditions for two study sites are shown in Figure 24, Travel Times Approach Volumes at Two Selected Study Sites. These sites provided the desired compatible variance in traffic volumes throughout the study period while holding other variables constant, e.g., width of travel area around the work site (net roadway), day of week, and climatic conditions.

Table 25, Listing of Study Site Physical Conditions and 15-Minute Approach Volumes and Distance of Long Section, and Table 26, Comparison of Travel Times Under Normal and Obstructed Conditions.

Referring to site No. 1 in Table 26, note that the average overall delay is 14 seconds. This is the difference in average overall travel time during obstructed conditions (56 seconds) and normal conditions (42 seconds). A review of the average overall delay for each study site shows that ten are *negative*, indicating a lesser travel time under *obstructed* conditions. Except under unusual conditions, it is unlikely that such obstructions actually improve traffic flow (increase speed). The only probable exception would be a situation encountered where traffic signals were coordinated for travel speeds *greater* than those recorded during normal conditions. Further investigations



SITE 1

SITE 2

FIGURE 24 TRAVEL TIMES AND APPROACH VOLUMES AT TWO SELECTED STUDY SITES

TABLE 25
LISTING OF STUDY SITE PHYSICAL CONDITIONS, 15 MINUTE APPROACH VOLUMES AND DISTANCE OF LONG SECTION

Study Site No.	City	15 Minute Volume		Site Loc.[1]	Street Type[2]	Avail. Width (ft)	Avail. No. of Lanes		Distance (ft)
		Before	During				Before	During	
1	Baton Rouge	110	128	4	1	10	2	1	1,760
2.	Baton Rouge	106	101	4	2	12	2	1	3,490
3.	Baton Rouge	256	267	2	5	11	2	1	2,420
4.	Seattle	134	129	4	2	12	2	1	4,390
5.	Seattle	94	77	4	2	9	2	1*	4,010
6.	Seattle	94	97	4	2	10	2	1	4,870
7.	Wichita	120	131	4	1	10	3	1	3,665
10.	San Diego	60	66	3	1	24	3	2	1,520
11.	Jacksonville	76	77	2	2	10	1	1*	2,042
12.	Jacksonville	10	5	4	2	13	1	1†	1,309
13.	Jacksonville	71	39	4	2	20	1	1*	1,550
15.	Minneapolis	207	214	1	1	41	3	2	1,265
16.	Minneapolis	–	–	1	2	20	2	2	815
21.	Montreal	180	142	3	1	24	2	2	3,517
23	Phoenix	–	–		2	20	2	1	1,173
24.	Phoenix	–	–		6	10	2	1*	2,652
26.	Columbus			4	1	37	4	3	2,879
28.	Columbus	194	216	2	6	19	2	1	4,956
29.	Des Moines	276	249	1	1	44	4	3	1,052
30.	Des Moines	7	11	4	1	14	1	1†	1,326
32.	Montreal	336	258	1	2	23	2	2	2,037
33.	Oakland	66	104	4	2	6	1	1*	2,300
34.	Oakland	132	117	2	2	7	2	1*	4,557
35.	Oakland	276	206	1	1	25	3	2	3,155
36.	Baltimore	268	309	1	1	31	4	3	705
37.	Baltimore	570	390	1	1	18	3	2	2,545
38.	Portland	87	90	1	1	24	3	2	1,090
40.	Atlanta	72	65	2	2	12	2	1*	2,340
41.	Atlanta	106	158	2	2	18	3	2	2,260
40′.	Greensboro	126	122	2	2	22	3	2	4,165
41′.	Greensboro	100	120	2	2	11	2	1	1,110
42.	Greensboro	106	95	2	2	11	2	1*	1,110
43.	Greensboro	126	144	2	2	11	3	1	1,380
44.	Greensboro	126	149	2	2	11	3	1	1,380
45.	Winnipeg	68	54	1	1	16	2	2	3,700
46a.	Winnipeg	201	182	1	1	24	3	2	2,680
46b.	Winnipeg	243	222	1	1	24	3	2	2,680
47.	Oakland	255	186	1	1	33	3	3	3,155

[1] Site Location Legend:
1. Central Business District
2. Outlying Business District
3. Fringe
4. Residential

[2] Street Type Legend:
1. Undivided One Way
2. Undivided Two Way
5. Divided Raised Median
6. Divided Flush Median

*Crossover – At Least One "Normally" Opposing Lane Was Used Exclusively for Primary Direction Traffic

†At Least One Lane Was Used to Carry Traffic in Both Directions

TABLE 26
COMPARISON OF TRAVEL TIMES UNDER NORMAL AND OBSTRUCTED CONDITIONS

	NORMAL		OBSTRUCTED			DIFFERENCE	
Study Site No.	No. Runs	Mean Time, Sec.	No. Runs	Mean Time, Sec.	Average Overall Delay Sec.	Stop Delay, Sec.	Travel Delay, Sec.
1	12	42	12	56	14	0	14
2	12	74	12	77	3	0	3
3	12	49	13	57	8	1	7
4	15	164	5	150	-14	-23	9
5	12	36	6	97	1	0	1
6	18	136	2	122	-14	-8	-6
7	9	120	27	112	-8	-8	0
10	19	71	13	78	7	6	1
11	4	123	4	150	27	8	19
12	6	44	4	56	12	5	7
13	8	38	3	41	3	0	3
15	4	54	5	84	30	27	3
16	4	57	5	76	19	31	-12
21	7	96	5	78	-18	-8	-10
23	15	45	15	47	2		2
24	9	119	24	181	62		
26	7	88	9	126	38	0	38
28	2	123	5	270	147	70	77
29	6	77	6	80	3	-2	5
30	3	56	2	65	9	2	7
32	7	86	5	97	11	12	-1
33	2	73	4	73	0	-5	5
34	2	165	2	160	-5	4	-9
35	24	145	17	169	24	15	9
36	6	112	8	90	-22	-27	5
37	19	117	11	111	-6	-4	-2
38	6	68	6	72	4	3	1
40	23	88	6	75	-13	-11	-2
41	24	99	6	128	29	34	-5
40′	3	74	12	83	9	3	6
41′	3	27	2	53	26	20	6
42	3	28	6	40	12	3	9
43	3	30	6	38	8	0	8
44	3	30	6	40	10	0	10
45	29	204	11	208	4	-5	9
46a	12	107	13	122	15	16	-1
46b	12	145	8	133	-12	-11	-1
47	6	163	7	138	-23	5	-28

ruled out this possibility in these nine studies. Therefore, the negative delays were considered as evidence of large inherent errors in measuring travel times.

The mean of the 38 average overall delays is 10.58 seconds and the standard deviation is 28.6 seconds. These produce a t-value of 2.28 which indicates that the mean of 10.58 differs significantly from 0 at the 0.05 level.

Recognizing that some of the 38 average overall delays were based on very few test-vehicle runs, an attempt was made to compensate for this weakness by a weighted mean of the 38 values with weight equal to the sites having a smaller number of runs. That is, a site with many runs under each condition will receive a "heavy" weight and a site with few runs under at least one condition (normal or obstructed) will receive a "light" weight. With this procedure, the weighted mean of the observed delays is 8.92 seconds, which is slightly less than the unweighted result of 10.58 seconds.

Once average overall delay had been calculated for each site an attempt was made to determine if a relationship existed with significant site characteristics such as number of available lanes, traffic volumes, street type, taper ratios, and location within the metropolitan area.

The frequency, mean, and standard deviation of average overall delay by metropolitan location for long section study sites is shown in Table 27.

One of the four means in Table 28 (104.5), Frequency, Mean and Standard Deviation of Average Overall Delay by Street Type for Long Section Study Sites, is significantly different from two of the other means (3.69 and 6.63).

TABLE 27

Frequency, Mean and Standard Deviation of Average Overall Delay for Long Section Study Sites by Metropolitan Locations

Site Location	Frequency	Mean	Std. Dev.
1. Cen. Bus. Dist.	12	3.92	17.24
2. Outlying Bus. Dist.	11	23.45	42.95
3. Fringe	2	−5.50	17.68
4. Residential	11	4.00	14.71

TABLE 28

Frequency, Mean and Standard Deviation of Average Overall Delay for Long Section Study Sites by Street Type

Street Type	Frequency	Mean	Std. Dev.
1. Undivided One Way	16	3.69	18.03
2. Undivided Two Way	19	6.63	12.98
5. Divided Raised Median	1	8.00	–
6. Divided Flush Median	2	104.50	60.10

In plotting average overall delay against corresponding 15-minute volumes per lane under obstructed conditions, an attempt was made to determine if a relationship existed, but this comparison also yielded no statistically significant relationship. The correlation coefficient is only .32. Because of reduced capacity and increased lane volumes existing under obstructed conditions, this attempt was expected to show the greatest relationship of all the independent variables. Before determining if a relationship exists between average overall delay and location within the metropolitan area, an attempt was made to correlate lane volumes under obstructed conditions with the two components of average overall delay, namely, average stop delay and average travel delay. The results show that each component correlates even less than average overall delay, with correlation coefficients of .41 and .70 for average stop delay and average travel delay, respectively.

No relationship can be found in Figure 25, Average Overall Delay – 15-Minute Volume per Lane Relationship by Location in Metropolitan Area for Long Section. Figure 26, Average Overall Delay – 15-Minute Volume per Lane Relationship by Street Type for Long Section, follows.

Except for one high mean shown in Table 28 of 45.0, the first steps in the analysis phase failed to produce a meaningful relationship between average overall delay and site characteristics or repair characteristics.

Since the results of the first step in the analysis phase did not appear to be significant, a different approach was taken to solve the problem.

An in-depth statistical analysis was not made for average overall delay recorded for

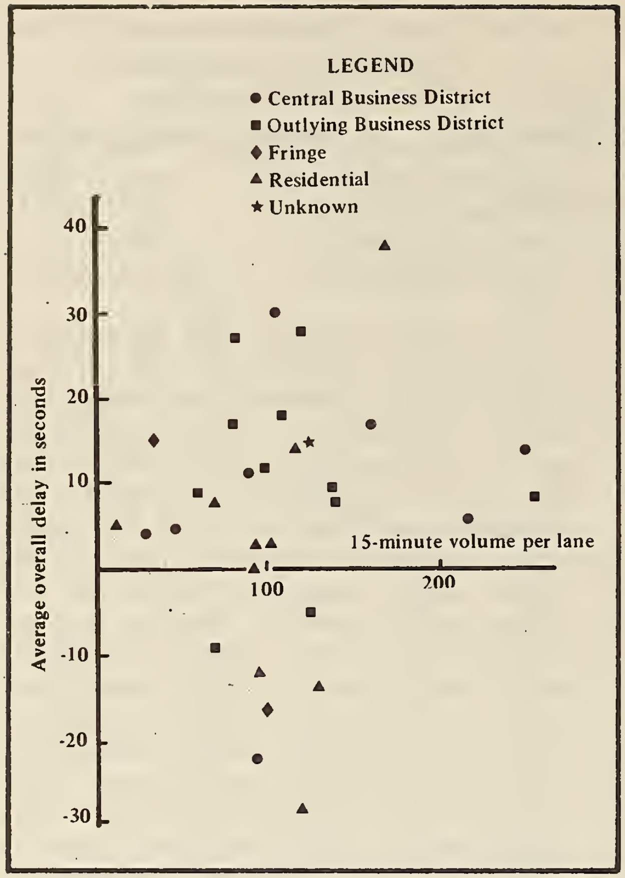


FIGURE 25 AVERAGE OVERALL DELAY – 15-MINUTE VOLUME PER LANE RELATIONSHIP BY LOCATION IN METROPOLITAN AREA FOR LONG SECTION

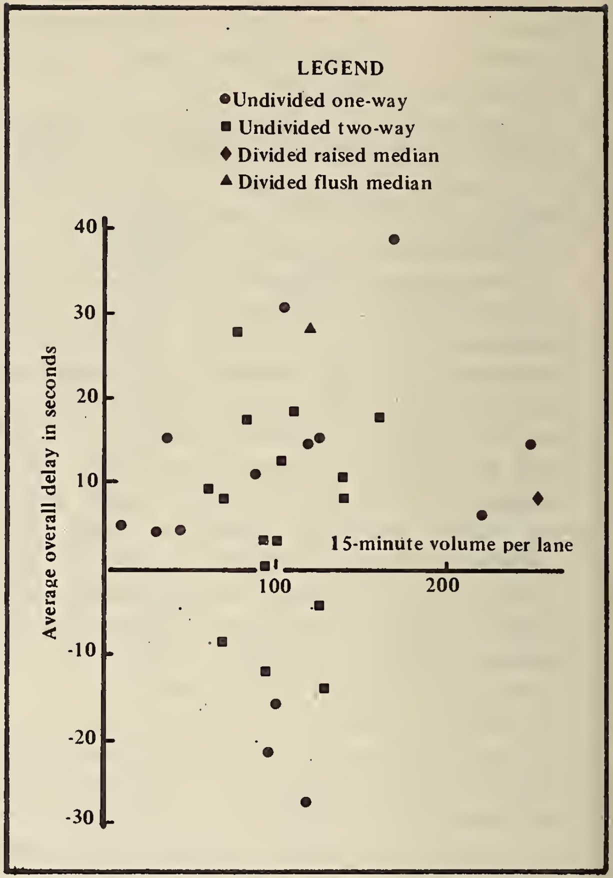


FIGURE 26 AVERAGE OVERALL DELAY – 15-MINUTE VOLUME PER LANE RELATIONSHIP BY STREET TYPE FOR LONG SECTION

the *short* section (Table 29, The Average Overall Delay, Veh. Sec., Categorized by Independent Variables), since the *short* section mean was found to be only 10 seconds.

Individual Evaluation

During the first and second stages of evaluation, no significance was placed on comparing like data related to traffic volumes. For example, the average overall travel times recorded under *obstructed* conditions during AM peak, AM off-peak, PM peak and PM off-peak periods might be compared with only those recording during the PM peak period under *normal* conditions. Averaging results of test-vehicle runs during these periods might result in a lesser average overall travel time for the runs made under *obstructed* conditions than if only the PM peak was used. It was hypothesized, then, that greater average overall delay would result from comparing only like data since, on purely rational grounds, one would expect the delay to be related to traffic volumes – volumes which normally are greater in PM periods (particularly on streets where adjacent land use is commercial, e.g., CBD).

Average overall delay was calculated at sites offering like study periods, e.g., AM peaks for both normal and obstructed conditions during stage two of the analysis phase. This factor and certain other related data were categorized by average daily traffic ranges per site location according to the general street types of one-way and two-way

TABLE 29
AVERAGE OVERALL DELAY, VEHICLE SECTION CATEGORIZED BY INDEPENDENT VARIABLES

Site Location	Aver. Daily Traffic Range	No. Travel Lanes Utilized		Capacity Loss		Delay in Veh. Sec.	Time of Studies (Approximate)	Site No.	Traffic Signal Influence	
		Normal	During	No. Lane	Percent Lanes				Yes	No
Residential Area	1,000-2,500	2	1	1	50	3.9	9:23–10:14 a	30		●
	2,501-5,000	2	1	1	50	6	7:30–8:00 a	01		●
	5,001-10,000	-	-	-		-	—	-		
	10,001-15,000	3	1	2	33	6.0	9:15–10:15 a	07		●
	15,001-20,000							26*	●	
Central Business District	2,500-5,000	2	2	0	0	13.4	9:04–11:32 a	45		
	5,001-10,000							38*	●	
	10,001-15,000	3	2	1	33	9.3	10:36a–1:18 p	15	●	
		3	2	1	33	-5.0	8:18–10:49 a	46(a)	●	
		3	2	1	33	-14.8	2:27–3:35 p	46(b)	●	
		3	2	1	33	77.7	11:30a–1:00 p	35	●	
								47*	●	
	15,000-20,000	4	3	1	25	1.0	12:40–1:30 p	29	●	
		4	3	1	25	2	2:00–2:30 p	36	●	
	20,001-25,000	3	2	1	33	8	9:04–9:48 p	37	●	
Outlying Business District	None									
Fringe Area	2,500-5,000	3	2	1	33	10	7:30 a–1:15 p	10	●	
	5,001-10,000	-	-	-	-	-	—	-		
	10,001-15,000	-	-	-	-	-	—	-		
	15,001-20,000	2	2	0	0	2.5	9:00–11:30 a	21	●	
Residential	500-1,000	1	1	†	†	2.5	8:00–9:00 a	12		●
	1,001-2,500	-	-	-		-		-		
	5,001-10,000	2	1	1	50	1.8	7:30–8:00 a	02 (P)		●
		2	1	1	50	5.9	7:42–8:05 a	02 (O)		●
	10,001-15,000	1	3/4	1/4	25	1.0***	9:30–10:00 a	33		
		2	1	1	50	(-)8.3	1:30–2:00 p	04		●
		-	-	-	-	-		05**		●
		-	-	-	-	-		06**		
	Not Available	2	1/2	1/2		65.4	8:15–9:00 & 10:00–11:30	24	●	
Central Business District	10,000-15,000	3	2	0	33	12.3	1:00–1:30 p	16†††	●	
	15,001-20,000	-	-	-	-	-	—	-		
	10,001-15,000	-	-	-	-	-	—	-		
	Over 25,001	*	*	0	0	-6.2	9:00–11:30 a	32	●	
	Not Available	2	1	1	50	3.2	9:20–10:50 a	23	●	
Outlying Business District	5,000-10,000	2	2	0††	0	25.0	9:45–11:00 a	11†††	●	
		2	0	2	0	-		40**	●	
	10,001-15,000	2	1	1	50	26.0	1:47–2:14 p	41′ ***	●	
		2	1	1	50	12.0	1:16–1:53 p	42***		●
	15,001-20,000	2	1	1	50	-	—	34*		●
		3	2	1	33	11.0	9:14 a–3:21 p	40′ ***		●
	20,001-25,000	2	1	1	50	8.5	9:27–10:17 a	03		●
		2	1	1	50	7.4	5:00–5:41 a	28		●
		3	2	1	33	14.2	3:58–5:28 p	41	●	
		3	1	2	67	4.2	9:08 a–2:32 p	43		●
		3	1	2	67	3.0	9:08 a–3:23 p	44		●

*	Not available information
**	Omitted because of lack of "like" data
***	Based only on one run "during" and one run "after"
†	One lane available for Two-way Traffic (Also utilized by const. equipment)
††	Prohibited parking to maintain travel lanes
†††	Affected intersectional traffic flow.

and are shown in Table 29. A comparison of Tables 28 and 29 reveals a reasonable *increase* in average overall delay for those sites calculated during the first step of the analysis. The most notable increase in average overall delay between the two analyses (stages) techniques for the *short* study sections, other than at the pilot study location, is attributed to study site number 35. Stage one techniques yielded 32 vehicle seconds of average overall delay while stage two yielded 78 seconds, an increase of 46 seconds.

An in-depth micro-analysis of study site 35 was made to determine if a relationship could be found between average overall delay and significant variables such as traffic signals and traffic volumes. Table 30, Comparison of Traffic Characteristics During Four Study Periods both During and After Activity at Study Site No. 35, compares traffic characteristics during four study periods – 8:00-9:00 AM, 11:30 AM-1:00 PM, 3:00-3:20 PM and 5:05-5:35 PM.

Throughout the four study periods, traffic volumes at the approach to the work site were greater in the "after" period (normal condition) than they were in the "during" (obstructed condition) period. The "during" studies were conducted on the second day of the seventeen-day construction period. This may account for the difference since some motorists who traveled over the study route on the first day of construction may have avoided driving the route on the following (study) day. Some vehicles, upon approaching the work site, may have elected to avoid the congestion by taking an alternate route.

Even though approach volumes were greater in the "after" period than the "during" period, no relationship appears to exist with average overall delay. Negative delay was found in study 35-A even though lane volumes recorded under obstructed conditions ("during" period) were greater than those recorded under normal conditions. The opposite lane-volume situation occurs in study 35-C where positive delay was found. The number of available lanes around the work area in study 35-D was questionable and, depending on the number of lanes, the lane-volume situation changes. Therefore, no correlation can be found between average overall delay and traffic volumes in study site number 35 or any of its substudies.

In reviewing stop delays for the substudies attributed to the immediate downstream signalized intersection, a trend emerges. With the exception of study 35-A, where no stop delay was recorded in either of the study periods, "during" and "after," the number and duration of stops may account for both negative and positive average overall

TABLE 30
COMPARISON OF TRAFFIC CHARACTERISTICS DURING AND AFTER ACTIVITY AT STUDY SITE NO. 35

Study No.	Study Time Period	Study Period	Average Overall Delay, Sec.	Stop Delay at First Downstream Signal: Time Sec.	Stop Delay at First Downstream Signal: Cause	No. of Lane	No. of Run	Aver. Speed, M.P.H.	Aver. Time Sec.	Average 15 Min. Traffic Volumes: Approach	Average 15 Min. Traffic Volumes: Lane
35-A	8:00 –	"During"	–5.2	-0-	None	2	5	24.0	14.8	221	110
	9:00 a	"After"		-0-	None	3	6	17.7	20.0	268	90
35-B	11:30 –	"During"	77.7	248	2 Sig./4 Sig. & C	2	6	3.1	113.3	216	108
	1:00 p	"After"		94	2 Sig./1 Sig. & C	3	6	9.9	35.7	359	120
35-C	3:00 –	"During"	45.0	76	3 Sig.	2	3	5.8	61.3	195	93
	3:20 p	"After"		-0-	None	3	3	21.7	16.3	211	70
35-D	5:05 –	"During"	–10.3	47	2 Sig.	2-3		8.3	42.7	194	97-67
	5:35 p	"After"		52	3 Sig.	3		6.7	53.0	250	83

delays found in studies 35-B, 35-C and 35-D. This is especially true of study 35-B where the test vehicle was required to make six complete stops in the "during" period as compared with only three stops in the "after" period – resulting in 77.7 seconds of average overall delay. Since the lane-volumes for the two study periods were very similar (108 "during" and 120 "after"), it appears that the signalized intersection was a much greater contributing factor in causing "delay" than were lane-volumes. Without further analysis, it might be concluded that the utility activity did not have a significant effect on traffic flow. However, omitting stop time recorded under both the "during" and "after" periods, average overall delay was found to be relatively significant at 49 seconds. The 49 seconds, however, cannot be attributed *in toto* to the utility activity, since running delay attributed to deceleration at the approach to the signalized intersection is not available. Nevertheless, a subjective analysis at this point would conclude that the utility activity was a significant contributing factor in average overall delay during study 35-B.

Since the work area was located at the approach to a signalized intersection, and since the traffic signal appears to be a major contributing factor in the average overall delay found in study 35-B, a capacity analysis was performed using procedures and data from the *Highway Capacity Manual.* A manual traffic count was not made at the intersection of Webster and 20th Streets. Therefore, for purposes of capacity analysis, 10 percent left turns, 10 percent right turns and 10 percent trucks and buses were assumed. Critical elements used in the analysis and the findings are listed in Table 31, Summary and Findings of Capacity Analysis at Webster Street Approach (One Way) to 20th Street (Two Way) in Oakland, California, Study Site 35. Note that the recorded peak-hour traffic volumes *exceeded* the calculated possible capacity (service volume) under both normal and obstructed conditions.

Since recorded demand volumes were found to exceed the calculated capacity under both normal and obstructed conditions, it might be concluded that the "individual" signal was an indirect cause for the average overall delay in study 35-B. Traffic signals on the route were coordinated to provide progression at speeds found under *normal* conditions. Referring once again to Table 30 it can be noted that when speeds were greater than 6.7 mph, with the exception of study 35-A, significant average overall delay is found. This may indicate that signal progression is a major contributing cause for the relatively significant average overall delays found in studies 35-B and 35-C.

After exploring all possibilities based on available data, it can be concluded that the

TABLE 31
SUMMARY AND FINDINGS OF CAPACITY ANALYSIS AT WEBSTER STREET APPROACH (ONE WAY) TO 20TH STREET (TWO WAY) IN OAKLAND, CALIFORNIA

Study Site 35

						Peak Hour		Level of Service		
Condition[1]	Approach Width, ft.	G/C Ratio	Green Time %	Metro Size & PHF Adjust,	Factor	Time	Volume Recorded	Volume, VPH Calculated	Level[4-5]	Adjust. Factor
Normal	45[3]	27/60	45	1.10	0.95	11:45 am – 12:45 pm	1,514	1,080	C	1.00
								1,400	E	1.30
Obstructed	17[2-4]	27/60	45	1.10	0.95	11:45 am – 12:45 pm	907	720	C	1.00
								828	E	1.15

[1] Assume 10% Trucks/Buses, 10% Left Turns and 10% Right Turns

[2] Assume 20 Feet for Use of Nomographs

[3] With Parking

[4] Without Parking

[5] C = Design Capacity, E = Possible Capacity

utility activity at study site 35 was a significant contributing factor to the average overall delay found in the study, especially if delay to motorists who may have utilized an alternate route is considered. The amount of delay might have been reduced if the signal timing had been adjusted for the utility impedance effect on the traffic stream. However, it should be noted that any improvement in travel time on the immediate study section might have had a detrimental effect on side-street traffic, as well as traffic on downstream sections on the study route, if signal timing had been adjusted for the activity conditions. Thus, these potential delays should be considered prior to any adjustment in signal timing on coordinated systems. The anticipated duration of the utility activity should also receive consideration in modifying signal timings during construction-maintenance activities.

Suggested Research

Three areas for future research emanating from this project include:

1. That data from each study site be further scrutinized for validity in terms of adequate number of comparable vehicle test runs, for both normal and obstructed conditions, and that the valid data be key punched for electronic data processing.
2. That traffic flows under the conditions (independent variables) experienced in this study be simulated with the use of a computer.
3. That further studies be conducted on arterial streets in business districts under the control of coordinated signal systems and that such studies also concurrently utilize the license-matching and arrival-output methods of gathering speed-flow data in addition to the floating vehicle techniques for comparing the relative merits of each technique.

APPENDIX F
MANUAL OF ADMINISTRATIVE PRACTICES FOR UTILITY INSTALLATIONS IN PUBLIC RIGHTS-OF-WAY IN THE CITY OF SAN DIEGO, CALIFORNIA

Introduction

The following manual was developed through a series of meetings between members of the staff of the City Manager of the City of San Diego and representatives of franchised utilities operating in the streets of the city.

Its history is as follows:

The franchises granted to the San Diego Gas & Electric Company in 1970 require that company to cooperate with city officials to formalize, in writing, certain desirable administrative practices which, because of their detail and possible change from time to time, were not appropriate to the franchise documents. The San Diego Gas & Electric Company was further required by the franchises to review this manual with the City annually hereafter.

It was the expressed intention of the City Council that this manual would apply to all city-owned and all franchised utilities operating in public *rights-of-way* in the city and would be included by reference in all future franchises.

The undersigned, by their signatures, approve this manual and accept the provisions as binding for a period of at least one year from the date of City Council approval; and further agree to cooperate with the City to review and revise the manual as necessary at the end of one year from the date of City Council approval; provided, however, that should there be any conflict between the provisions of this manual and the franchises granted by ordinance of the City Council to any signatory hereof, the provisions of that particular franchise shall govern as to that particular signatory.

Signed by: City of San Diego
San Diego Gas & Electric Company
Applied Energy, Incorporated

Approved by City Council by Resolution No. 205629. Date, May 18, 1972.

Cathodic Protection

For purposes of this manual the term "cathodic protection" shall mean control of external corrosion on underground or submerged metallic systems.

Utilities maintaining installations in public rights-of-way shall provide cathodic protection in accordance with the recommended practice of the National Association of Corrosion Engineers (NACE) as more particularly contained in Standard RP-01-69 for Control of External Corrosion on Underground or Submerged Metallic Pipe Systems; except that, when Department of Transportation or California Public Utilities Commission requirements are in conflict with the NACE standard, the Department of Transportation and/or the California Public Utilities Commission requirements shall govern.

All city-owned and all franchised utilities shall provide and maintain active membership of responsible personnel on a joint committee, sponsored by the city, which shall meet on a regular basis to serve as an informational clearinghouse and policy-setting body on this subject.

Responsible City Department: Water Utilities

Standard RP–01–69 available at: Records Center, 3rd floor, City Operations Building

Responsibility for performance rests with: Each utility

Coordination

All utilities with installations in the public rights-of-way shall maintain responsible membership on a Utilities Coordination Committee, sponsored by the city which shall meet at least once a month throughout the year.

The city shall be represented on this committee by the following departments: Water Utilities, Public Works-City Engineer, Community Development.

The committee shall have as its objectives:

(1) to compare and coordinate construction schedules, to achieve maximum efficiency in work and minimum inconvenience and cost to the public;

(2) to foresee future problems in construction, environmental and aesthetic, as well as functional, and report these problems to the planning groups of the organizations they represent; and

(3) to review on a continuing basis all laws and regulations which affect the installation and maintenance of utilities, and recommend needed revisions to their respective managements.

The management of all utilities agree to consider all committee referrals, and to meet, as needed, to reconcile differences.

Responsible City Department: Public Works-City Engineer

Responsibility for performance rests with: Each utility

Emergency Repairs

Incidental damage done by one utility to another's installation shall be handled on an informal basis, each utility repairing its own installation.

When a utility feels that a specific case of considerable damage to its facilities has been caused by a lack of coordination, or by inadequate investigation or negligence on the part of another utility or the city, and the damaged utility feels that the above rule is unjust, the case should be brought before the Utilities Coordination Committee for review and recommendations.

Responsible City Department: Public Works-City Engineer, Water Utilities

Responsibility for performance rests with: Each utility

Overhead Installations

The installation of overhead distribution facilities in any area that has either been converted to underground facilities or originally constructed with underground facilities is prohibited; except when, due to excessive cost or other good and sufficient reason, the City Council grants a waiver of the undergrounding of facilities pursuant to provisions of the San Diego Municipal Code, for a limited time only.

Responsible City Department: Community Development

Pavement Cutting

Utilities maintaining installations in the public rights-of-way shall exert every effort, in long range planning and through active participation in the work of the Coordination Committee, to avoid longitudinal cuts in new street surfaces within three years of paving, and in slurry seal or other resurfacing within one year after surfacing has been placed.

Responsible City Department: Public Works-City Engineer

Responsibility for performance rests with: Each utility

Records

All utilities with installations in the public rights-of-way shall arrange to maintain records relating the location of such utilities to the California Coordinate System; except that:

A utility which, prior to issuance of this manual, has adopted a different but compatible coordinate system may continue to use that system, provided it furnishes to the Records Center of the City's Public Works-City Engineer Department a conversion formula for the San Diego area.

All utilities shall maintain up-to-date records on their utility locations, and shall agree to furnish information concerning them promptly upon request to the city, other agencies, private engineers or contractors, or any other persons or groups having need of such knowledge.

It is understood that such records are approximate; and that pot-holding should be requested, and performed, whenever the exact horizontal and vertical placements are required.

Responsible City Department: Public Works-City Engineer

Information on California Coordinate System available at: Records Center, 3rd floor, City Operations Building

Responsibility for performance rests with: Each utility

Relocation of Utilities

All utilities maintaining installations in the public rights-of-way are required to relocate these utilities whenever such relocation is necessary to accommodate public improvements required by city.

The expense of such relocation shall be borne as follows:

(1) By city and/or by developer: Where utility installation was made prior in time to the dedication of the public right-of-way

(2) By utility: In all other cases, except as follows –

(3) Where City and/or developer require relocation to conform to, but prior to implementation of, the public improvement, developer shall pay any extra costs due to the piecemeal nature of the relocation.

Responsible City Departments: Community Development, Public Works-City Engineer

Information available from: Community Development, Subdivisions Section, 4th floor, City Operations Building

Responsibility for performance rests with: Each utility

Safety and Traffic Control

The utility working in the street shall be responsible for the safe movement of traffic through its construction and maintenance operations. Signs, warning devices and general conditions of safety shall be as detailed in the 1966 edition of the San Diego and Imperial Counties Chapter of the American Public Works Association Traffic Control Manual, with the following exception:

> Nonconventional barricades – oil drums, concrete standards, metal pipes, sandbags, etc. – are no longer permitted. All large construction barricades with heavy bases are prohibited except when they are deemed necessary to separate the motorist from an obstruction of greater hazard than the barricade itself.

However, insofar as any signatory to this manual is governed by the Williams-Steiger Occupational and Health Act of 1970 (29 U.S.C.A. 650 et seq.), said provisions or any regulations issued pursuant thereto shall apply to said signatory in lieu of those set forth above.

As of this writing, the National Committee on Uniform Safety Control Devices is preparing new specifications for barricades and warning signs. Once these are released and the State of California has indicated approval, the APWA Traffic Control Manual will be revised. That revision, expected sometime in 1972, will succeed the 1966 edition as the standard specifications for safety and traffic control in the City of San Diego.

Responsible City Department: Public Works-City Engineer

Specifications available at: Records Center, 3rd floor, City Operations Building

Responsibility for performance rests with: Each utility

Trench Restoration

All utilities involved in trench excavation within the public rights-of-way shall install permanent surfacing, subject to Section 306-1 through 306-1.12.1 of the American Public Works Association Standard Specifications, 1970 Edition, and by one of the following options:

Option A – Permanent Trench Cover

Unless otherwise indicated on the plans and/or specified in the Special Conditions, the replacement of pavement shall be accomplished within 72 hours after completion of backfill as follows:

In areas where the wearing surface is asphaltic concrete, the contractor shall replace the pavement with an early strength Class A Portland cement concrete base and a 1½-inch asphaltic concrete surface course. Said concrete base shall be finished to 1½ inches below adjacent pavement but not less than 5 inches thick on alleys or residential streets, nor less than 7 inches thick on major secondary streets and highways.

In areas where the wearing surface is Portland cement concrete, the contractor shall replace the pavement with early strength Class A Portland cement concrete pavement. Said concrete pavement replacement shall conform to the original location and elevation as nearly as possible and shall be of the same depth as the original pavement, but not less than 6 inches thick on alleys or residential streets, nor less than 8 inches thick on major or secondary streets or highways.

Option B – Permanent Trench Cover

Unless otherwise indicated on the plans and/or specified in the Special Conditions, the replacement of pavement shall be accomplished within 72 hours after completion of backfill as follows:

I. Openings in existing concrete pavements. Pavement to be restored in kind but with early strength Class A Portland cement concrete

II. Transverse services, pits, exploratory holes, and/or longitudinal trenches less than one block in length, in standard asphalt pavement or pavements with asphaltic surfaces.

Pavement to be restored as follows:

Step 1: Place early strength Class A Portland cement concrete *flush* with adjacent pavements to:
  a. 6-inch depth on residential streets or alleys;
  b. 8-inch depth on major and collector streets (40 feet or over in width).

Step 2: Apply a black bituminous-based curing compound (Sealtex or equal) as soon as water sheen has left concrete

Step 3: Open to traffic when cured, but not later than 48 hours after pavement placement

Step 4: Within two months, apply a sanded bituminous seal to those restored areas, in such manner as to overlap the surrounding pavement and seal the edge of the patch

III. Longitudinal trench cuts of one block or more in length

Steps 1, 2 and 3: Same as II above

Step 4: Within six months, apply a two-pass, quick-set slurry seal coat, first pass to overlap both edges of the longitudinal trench by at least a foot, second pass to be full width from curb to curb. (Exception: Those streets which, prior to the subsurface installations or repairs, are deemed eligible for being included in a plant-mixed resurfacing program.)

Responsible City Department: Public Works-City Engineer

Specific information available at: Records Center, 3rd floor, City Operations Building

Responsibility for performance rests with: Each utility

Utility Locations

All utilities placed in the public rights-of-way of the City of San Diego shall occupy the locations indicated in City of San Diego Standard Drawing P-24-71; except when, due to specific conditions which would make such locations impractical, permission for variance is given in writing by the Director of Public Works.

The location of chilled water lines within public rights-of-way will be approved by the Director of Public Works on a case-by-case basis, due to the limited extent of the system and the peculiar grade problems which must be considered.

Utilities already existing in nonstandard locations may be replaced in the same locations.

Responsible City Department: Public Works-City Engineer

Standard Drawing available at: Records Center, 3rd floor, City Operations Building

Responsibility for performance rests with: Each utility

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